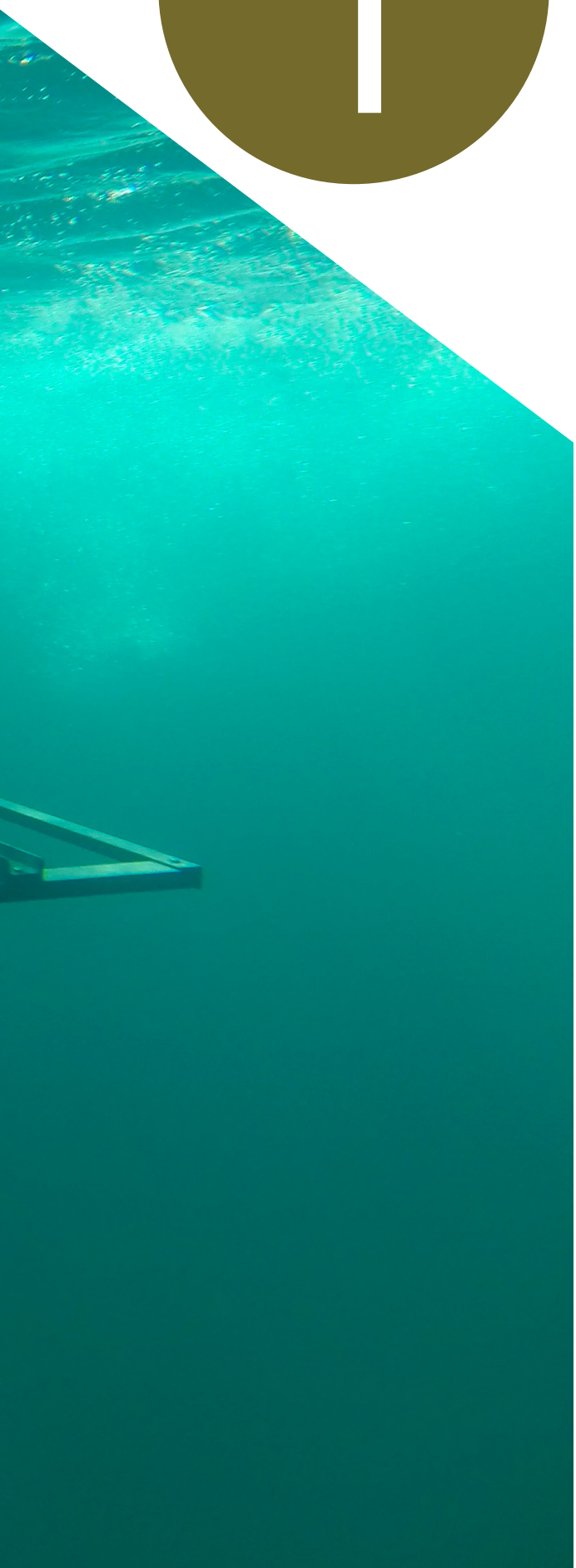

Chapter 1

Marine Research

Authors

Jan Mees [1]
Hans Pirlet [1]
Ann-Katrien Lescrauwaet [1]
Thomas Verleye [1]
Ruth Pirlet [1]
Colin Janssen [2]
Gert Verreet [3]

Reviewers

Rudy Herman [4]
Kristien Vercoutere [5]
David Cox [6]

[1] Flanders Marine Institute (VLIZ)
[2] Chairman VLIZ Scientific Committee
[3] Science, Technology and Innovation department (EWI)
[4] Emeritus senior researcher EWI
[5] Flemish Council for Science and Innovation (VRWI)
[6] BELSPO

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1. Introduction

Seas and oceans play a crucial role in the overall functioning of the earth: they absorb a large part of the atmospheric carbon dioxide, and are estimated to produce more than half of the oxygen that is available for life on earth (*Field et al. 1998*, *Behrenfeld et al. 2006*). As a storage of energy, oceans have a major impact on climate and the watercycle. Moreover, seas and oceans contain a significant part of the biological diversity on the planet (*Appeltans et al. 2012*, *WoRMS Editorial Board 2013*). In economic terms, the importance of oceans is still growing: they are a major source of food, water, energy and natural resources, generate a high economic turnover from tourism and provide the backbone of European international trade. However, our oceans are not inexhaustible or indestructible. Signs of increasing human pressures and impact on the quality of the environment are everywhere. Still, oceans remain the least explored and studied realm on earth. Multidisciplinary scientific research is crucial for understanding global processes and ecosystem functioning. This knowledge is needed for sustainable development of our growing maritime economies, and is essential for the prospective management of ecosystems towards a sustainable future. Immediate action is recommended on urgent questions such as food security, security of water and energy, climate change, and the welfare of humanity (*Rome Declaration 2014*).

This chapter provides an overview of marine research in a global, European and local context. It maps the marine research landscape in Flanders and in Belgium, building on quantitative measurements related to research capacity, research resources and knowledge output. As such, it provides a review of the expertise and diversity of the marine research community.

1.1 Marine research: global context

Oceans and seas can be considered as a single and highly connected living environment. Therefore, marine research must be approached on a global level. Several initiatives and organisations make the effort to coordinate their marine research programmes at an international level.

The Intergovernmental Oceanographic Commission (*IOC*) of the United Nations Educational, Scientific and Cultural Organisation (UNESCO) is mandated for the global coordination and execution of programmes for research and observation of the oceans, exchange of oceanographic data and information, services and training (table 1).

The *UN-OCEANS* network promotes a higher level of cooperation between UN bodies on a global level: the Convention on Biological Diversity (*CBD*), the International Maritime Organisation (*IMO*), the International Seabed Authority (*ISA*), the UN Environmental Programme (*UNEP*), the UN Development Programme (*UNDP*) and the Intergovernmental Panel on Climate Change (*IPCC*) are of particular relevance for marine and coastal research.

The UN Conference *Rio+20*, which took place 20 years after the first meeting (1992) in Rio de Janeiro (Brazil), focuses on a global agenda for sustainable development with a specific chapter on seas and oceans. In September 2015 the world leaders agreed on a set of Sustainable Development Goals (SDGs), of which *SDG 14* addresses the oceans (*Transforming our World: the 2030 Agenda for Sustainable Development*).

In the framework of the United Nations Convention on the Law of the Sea (*UNCLOS*, 1982) there are several international organisations responsible for policy making and management of activities such as shipping and fisheries and their effects on the environment. In support of these tasks, research and technological innovation are carried out. Recent developments focus on the expansion of activities such as the exploration of the Arctic waters and the deep sea, where important scientific, technological and policy challenges need to be addressed.

At the global level, a number of research networks and programmes focus on marine research (see table 2).

Table 1. Programmes for marine research, data management and training of the Intergovernmental Oceanographic Commission (*IOC*-UNESCO).

PROGRAMMES FOR MARINE RESEARCH, DATA MANAGEMENT AND TRAINING OF IOC-UNESCO		
Ocean Science Section - research coordination	Ocean acidification / ocean carbon	*Ocean Acidification* International Ocean Carbon Coordination Project (*IOCCP*)
	Climate change and adaptation	World Climate Research Programme (*WCRP*) Climate Change and Ecosystems, Coral Reefs (*GCRMN*) Climate Change and Ecosystem Dynamics (*GLOBEC*) Adaptation Climate Change in Africa (*ACC Africa*)
	Harmful algal blooms	Harmful Algal Bloom Programme (*IOC-HAB*) Global Oceanography and Ecology of Harmful Algal Blooms (*GEOHAB*)
	Marine spatial planning	Marine Spatial Planning Initiative (*IOC-MSP*)
	Integrated coastal zone management	Integrated Coastal Area Management (*ICAM*) Southeast Pacific Data and Information Network in support to Integrated Coastal Area Management (*SPINCAM*) *Integrated Coastal Research – nutrient management* and Nutrients and Coastal Impacts Research Programme (*N-CIRP*)
	Marine biodiversity	Ocean Biogeographic Information System (*OBIS*)
	Global environmental reporting	UN Regular Process (*UN Reg Process*) and Assessment of Assessments (*World Ocean Assessment*)
Operational data collection and observation of the oceans	Global Ocean Observing System (*GOOS*) Joint Technical Commission for Oceanography and Marine Meteorology (*JCOMM*, jointly with *WMO*) International Oceanographic Data and Information Exchange (*IODE*); including Ocean Biogeographic Information System (*OBIS*)	
Data networks, data portals, data centres	IODE National Oceanographic Data Centres; includes the Belgian Marine Data Centre (BMDC) (RBINS-OD Nature) and VLIZ data centre (VLIZ) in Belgium IODE Regional Ocean Data and Information Networks (*ODINs*): *ODINAFRICA*, *ODINCARSA*, *ODINCINDIO*, *ODINECET*, *ODINWESTPAC*, *ODINBLACKSEA* *IODE Ocean data Portal*, World Ocean Database 2009 (WOD09)	

Table 2. Global marine research networks and programmes.

ORGANISATION	DESCRIPTION
POGO	Partnership for Observation of the Global Oceans
WAMS	World Association of Marine Stations
CoML	Census of Marine Life
IGBP	International Geosphere-Biosphere programme, sponsor of the projects: Integrated Marine Biogeochemistry and Ecosystem Research (*IMBER*), Land-Ocean Interactions in the Coastal Zone (*LOICZ*) and International Surface Ocean - Lower Atmosphere Study (*SOLAS*)
WCRP	World Climate research Programme, sponsor of Variability and Predictability of the Ocean-Atmosphere System (*CLIVAR*)
GEOTRACES	International Study of Marine Biogeochemical Cycles of Trace Elements and their Isotopes
Future Earth Programme	*Science and Technology Alliance for Global Sustainability*; a collaborative effort of different partners including the International Council for Science (*ICSU*) and its Scientific Committee on Oceanic Research (*SCOR*); UNESCO; UNEP; WMO
DIVERSITAS	Integration of biodiversity research at the global level; participation of different UN-partners
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services; participation of different UN partners
OECD	Organisation for Economic Cooperation and Development: research on Marine Biotechnology (*OECD 2013*) and economic use of the oceans (*Future of the Ocean Economy*)

1.2 Marine research: European context

EUROPEAN POLICY FOR RESEARCH AND INNOVATION

European Commission - General science policy and organisation

The Directorate-General for Research and Innovation (*DG R&I*) of the European Commission (EC) is responsible for European research and innovation policies. Its policy goals are oriented towards the European strategy for economic growth (*Europe 2020*) and innovation (*Innovation Union*), one of the 7 initiatives within the Europe 2020 Strategy. DG R&I is also responsible for the funding and the establishment of funding instruments for research and innovation, such as the European Framework Programmes (FPs). This includes the current 'eighth Framework Programme' *Horizon 2020* (regulation (EU) 1290/2013).

The European Research Council (*ERC*) is an independent entity within the DG R&I, and funds ground-breaking research conducted by outstanding scientists. The Marie Skłodowska-Curie actions (*MSCA*) aim to increase the interdisciplinary mobility of researchers and support strategic partnerships between hosting research institutes. The European Research Executive Agency (*REA*) of the EC is a funding body responsible for managing Horizon 2020 (together with *ERC*, the Executive Agency for Small and Medium-sized Enterprises (*EASME*) and Innovation and Networks Executive Agency (*INEA*)). Independent entities conducting specific research for the EC include the Joint Research Centre (*JRC*) and the European Environment Agency (*EEA*), supported by the European Topic Centers (ETCs) and the European Environment Information and Observation Network (*Eionet*).

European Commission – Marine networks and cooperation

Research on oceans and seas inherently involves high costs and relies on research facilities that are not always accessible to all European researchers. The alignment of objectives and the pooling of available financial resources and capacities allows to address challenges in an effective and coordinated way. Moreover, it stimulates the transfer of scientific information and knowledge towards research and innovative applications (*Navigating the Future IV, European Marine Board, 2013*, *Rome Declaration, 2014*, Marine Knowledge 2020 - COM (2010) 461).

Horizon 2020 facilitates and finances multidisciplinary research and innovation within different fields, technologies and disciplines. The agenda of this programme is strongly linked with the societal and policy context (*Pirlet et al. 2015a*, Guide to funding instruments). Horizon 2020 combines research funding with business-oriented funding for innovation measures, as well as funding coming from the European Institute of Innovation and Technology (*EIT*), to combine science, higher education and the launch of new goods and services. The seventh Framework Programme (FP7) already aimed at a strong EU leadership in the global knowledge-based economy (Europe 2020 Strategy), *inter alia* by building the European Research Area (*ERA*) to stimulate an open exchange of scientists and knowledge. The first steps in this process were the *ERA-NET projects*, a number of which were situated in the marine field, e.g. *MarinERA*, *AMPERA*, *MariFish* and *SEAS-ERA*.

Cooperation in research is also stimulated through the European Innovation Partnerships (*EIP*), Joint Technology Initiatives (*JTI*), Coordination and Support Actions (*CSA*) and the cooperation agreements on scientific research between and with member states as described in *Article 185* of the EU Convention. The European Strategic Forum for Research Infrastructure (*ESFRI*) supports a coherent and strategic approach to policies for research infrastructure in Europe. It facilitates initiatives leading to a better use and optimal development of this infrastructure at the European and international level. Three ESFRI initiatives are of particular relevance to marine research in Flanders and Belgium: the Integrated Carbon Observation System (*ICOS*) and its Ocean Thematic Centre (OTC), the E-Science European Infrastructure for Biodiversity and Ecosystem Research (*LifeWatch*), and the European Marine Biological Resource Centre (*EMBRC*). Flanders and Belgium do not take part in the other marine ESFRIs: European Multidisciplinary Seafloor and water column Observatory (*EMSO*) and *EURO-ARGO*.

Strategic research agendas and visions for the future

A number of networks and consortia with a strong representation of the European research community are oriented towards the development of a vision and preparation of strategic agendas for marine research. The European Marine Board (*EMB*) develops the interface between marine research and marine/maritime policies, and draws Position Papers on research priorities and strategies for European marine research such as *Navigating the Future IV* (figure 1).

The *EurOCEAN conferences* offer a platform for those involved in the research-policy interface, both at the European level and in the member states. These conferences allow the European research community to participate in shaping the European vision for marine research through the *Galway Declaration (2004)*, the *Aberdeen Declaration (2007)*, the *Ostend Declaration (2010)*, and the *Rome Declaration (2014)*. The *Brest Declaration (2011)* focuses on marine research infrastructure (figure 1).

In Europe, research agendas are mainly determined by the member states (for Belgium, see **Policy context for scientific research in Flanders/Belgium**). 88% of all public investments in research and development (R&D) are designed, financed and evaluated at national (and within Belgium also by the regions/communities) and local levels (*Acheson et al. 2012*). Joint Programming (JP) offers an integration and coordination platform for European member states in order to efficiently use the available national budgets and organisational resources for research; for example by drafting joint research agendas and aligning priorities for cooperation in the long term. Whereas the FPs are jointly managed at a European level, JP is characterised by a bottom-up approach with a variable geometry for participation. Since 2009, 10 Joint Programming Initiatives (JPIs) were launched, including the initiative for 'Healthy and Productive Seas and Oceans', also referred to as *JPI Oceans*, that adopted its *Strategic Research and Innovation Agenda 2015-2020* in the spring of 2015.

Other examples of partnerships between research institutes at the European level are the European Fisheries and Aquaculture Research Organisation (*EFARO*), the European Global Ocean Observing System (*EuroGOOS*), the European Network of Marine Research Institutes and Stations (*MARS*), the European Marine Research Network (*EUROMARINE*), the EU Technology Platforms *Waterborne* and *EurOcean*. Marine research is also an important component to support the operational tasks of different European and regional organisations regarding pollution, safety, dredging, etc.

DRIVERS FOR MARINE RESEARCH IN EUROPE

Different policy domains of the EC with regard to the oceans affect the European marine research in a significant way. The Integrated Maritime Policy (IMP, COM (2007) 575) is a cornerstone in these policies. The IMP aims at a more coherent approach to maritime affairs and a higher degree of coordination between the different policy domains involved. The IMP consists of a number of transversal policy instruments in the fields of Blue Growth (COM (2012) 494), Blue Innovation (COM (2014) 254), Marine Knowledge (COM (2010) 461) (see below), Maritime Spatial Planning (directive 2014/89/EU), Integrated Maritime Surveillance (COM (2009) 538) and the Regional Sea Strategies (*Verleye et al. 2015*) (figure 1). In the EU Marine Strategy Framework Directive (MSFD, 2008/56/EC) the member states agreed to achieve a Good Environmental Status (GES) in their marine waters by 2020. The MSFD addresses the environmental aspects of the IMP and is an important driver for marine research aiming to fill the knowledge gaps. It also provides a common framework and goals for the protection and conservation of the marine environment (see also theme **Nature and environment**).

The European strategy for marine and maritime research (COM (2008) 534) was drafted within the IMP, following the *Aberdeen Declaration (2007)* (figure 1). Its aim is to provide policy makers with the necessary scientific information in support of:

- The socio-economic importance of the maritime economy;
- The increasing pressures on the marine environment as a result of human activities and climate change;
- The increasing competition for marine space.

The strategy also aims at an Integrated Marine and Maritime Research Area (*DG R&I*).

Marine Knowledge 2020 (COM (2010) 461) is an important component within the IMP. This initiative aims at centralising marine data from different sources. The aim is to provide increased efficiency to access quality-checked marine data for industry, policy makers and scientists to support the development of new or improved products and services and increase our knowledge of the oceans. At the heart of Marine Knowledge 2020 is the European Marine Observation and Data network (*EMODnet*) which integrates marine data, data products and metadata from different sources in a uniform way through a web portal.

Besides the IMP, there are a number of sectoral (marine and maritime) policy instruments that provide guidance for marine research in a European context. Evident examples are the Common Fisheries Policy (CFP, regulation (EU) 1380/2013), and the implementation of the Water Framework Directive (WFD, 2000/60/EC), the Habitats Directive (92/43/EEC) and the Birds Directive (2009/147/EC) in marine areas and coastal zones (see also *Verleye et al. 2015*).

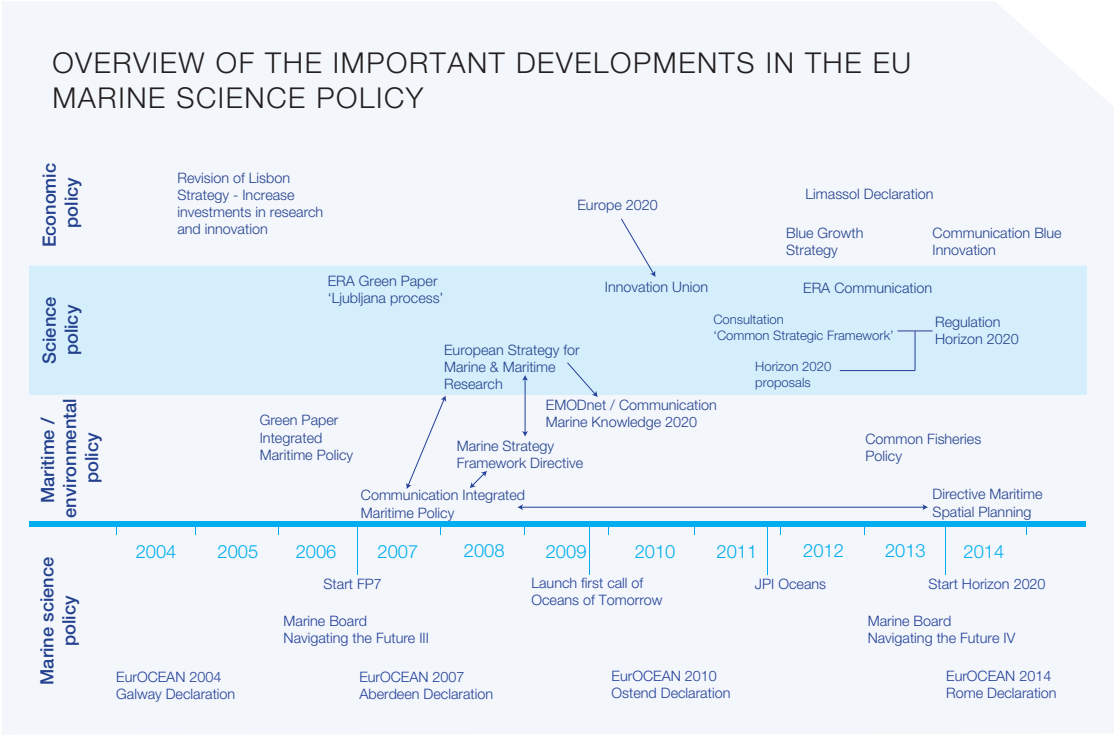

Figure 1. An overview of some of the important developments in the EU marine science policy between 2004 and 2014 (modified after *Navigating the Future IV (European Marine Board 2013)*).

Information systems in support of these policy instruments include the Data Collection Framework for the CFP (*DCF*), the Shared Environmental Information System (*SEIS*), the Water Information System for Europe (*WISE*) and WISE-marine (under construction), the Biodiversity Information System for Europe (*BISE*), the European Climate Adaptation Platform (*CLIMATE-ADAPT*) and *MyOcean*, the marine component of the COPERNICUS initiative (former GMES). The extent of what information is publicly available for researchers reveals important variations and the data policies of the different systems are evolving rapidly under the influence of the 'Open Access Movement'.

The science-policy interface within the framework of these policy instruments, as well as the actors involved, are discussed in more detail in the **Chapter 2 'Use of the sea'**.

REGIONAL SEA - THE NORTH SEA

The European Commission (EC) and the member states have established 'Regional Sea Basin Strategies' (in the framework of the EU regional policy, and/or of the Integrated Maritime Policy) for the Baltic Sea, Black Sea, Danube River Basin, Mediterranean Sea, Atlantic Ocean and the Arctic Ocean. In the framework of such strategic agendas, specific actions are agreed upon that provide guidelines to the entities involved for the implementation of their policy instruments. Hence, this will help them to reach their common goals more effectively. In the case of the North Sea no common strategy has been developed yet between the EC and the member states.

For the adjacent area of the Northeast Atlantic Ocean a maritime regional strategy (COM (2013) 279) was established by the following countries: Portugal, Spain, France, Ireland and the UK. In May 2013, during the Irish EU presidency, the EU, the USA and Canada jointly signed the *Galway Statement on Atlantic Ocean Cooperation (2013)* in order to launch a Transatlantic Ocean Research Alliance. The goal is to increase the collaboration and streamline the efforts of the partners in topics of ocean observation in the Atlantic Ocean, including the effects from the nearby Arctic Ocean. The cooperation also focuses on the marine research activities that are needed to underpin sustainable growth of the economic activities in the Atlantic. Furthermore, the action plan addresses the processes in the Atlantic Ocean which influence the climate.

Conventions at the level of regional seas exist, with the main focus on the protection of the marine environment (table 3).

Table 3. Conventions and declarations for the protection of the marine environment at the scale of regional seas.

CONVENTION / DECLARATION	REGION / REGIONAL SEA	TOPIC
OSPAR Convention (1992)	Northeast Atlantic Ocean, incl. North Sea (OSPAR-Region II)	Protection of the marine environment
Helsinki Convention (*HELCOM*, 2000)	Baltic Sea	Protection of the marine environment
Barcelona Convention (UNEP-MAP, 1978)	Mediterranean Sea	Protection of the marine environment
Bucharest Convention (Black Sea Commission) (1992)	Black Sea	Protection of the marine environment
Bonn Agreement (1969)	North Sea	Protection of the marine environment
ASCOBANS (1994)	Baltic Sea, Northeast Atlantic Ocean, Irish Sea, North Sea	Research and protection of small cetaceans and their living environment
Ministerial declarations and statements (1984-2006)	North Sea	Collaborative research on the environmental conditions and targets for marine pollution

The International Council for the Exploration of the Sea (*ICES*) is of great importance for the broader North Sea. ICES is a cooperation of 19 countries bordering the North Atlantic Ocean and adjacent seas with the aim to exchange scientific information, as well as to provide expert advice to governments and commissions of the European Union (EU) and Regional Sea Conventions OSPAR and HELCOM.

The *BONUS programme*, based on Article 185 of the EU Convention (TFEU), is a programme for research and development specially designed for the Baltic Sea, and jointly funded by the EU and the involved countries. In 2015 the potential expansion of BONUS towards the North Sea is under consideration.

EUROPEAN FUNDING INSTRUMENTS FOR MARINE RESEARCH

Overview and history of European funding instruments for research

The EU offers several instruments for the funding of research, depending on the goals, partnerships, structural embedding, budget requirements, etc. Currently the most important financial mechanisms include:

- *Horizon 2020* (2014-2020);
- The *Structural Funds*, including the European Regional Development Fund (*ERDF*) that finances the INTERREG programme (III, IV, 2 Seas);
- The European Maritime and Fisheries Fund (*EMFF*) (2014-2020) to support the CFP and IMP;
- The Programme for the Competitiveness of Enterprises and SMEs (*COSME*) (2014-2020).

Besides the aforementioned funding instruments, there are other mechanisms within the community programmes such as the Financial Instrument for the Environment (*LIFE*), the *EUREKA network*, *EUROCORES*, the European Cooperation in Science and Technology (*COST*), and *Regions of Knowledge*. An overview of the European funding instruments is available in the 'Guide to funding instruments for marine research and innovation projects' (*Pirlet et al. 2015a*).

Europe and the EC have conducted an active policy for international cooperation in research since the treaty that established the European Coal and Steel Community (ECSC) in 1952 (figure 2). Article 130f of the *Treaty for the European Union* calls for a reinforcement of science and technology as one of the foundations of the European industry. The FPs (figure 2, from 1984) were implemented according to the founding principles of the Treaty, aiming for an increased competitiveness at the international level and highlighting the need for research to underpin other EU policy goals.

Since FP1 (1984), the available EU budgets for research (FPs and other EU-financed programmes) have gradually increased in comparison to dedicated national resources for research and development (source: *DG R&I*). In the 1980s, the EU budgets for research and development (R&D) amounted to an average of 8% in comparison to the national budgets for R&D in member states. In the 2002-2005, the EU share in research funding slowly increased to

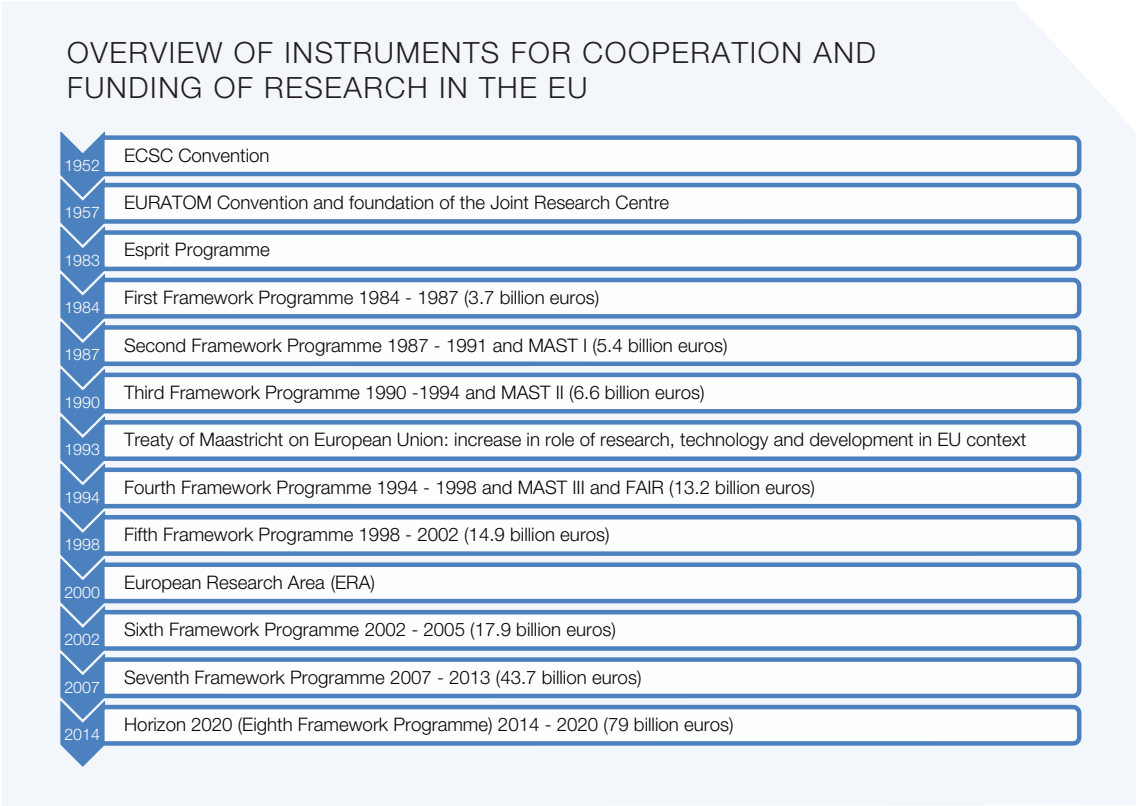

Figure 2. Chronological overview of instruments for collaboration and funding of research in the EU, with an indication of the available budget (Source: DG R&I).

an average of 15.3% compared to national research budgets (*Acheson et al. 2012*). *Horizon 2020* (regulation (EU) 1290/2013) runs from 2014 to 2020 with an approved budget of approximately 79 billion euros.

Relative importance of marine research in the European funding instruments

Depending on their research objectives, marine researchers can apply for different funding sources for the financing of their research projects and network activities. Although the FPs are the best known funding instruments, they do not necessarily have dedicated budget lines for marine research. FP2 contained a first dedicated Marine Science and Technology Programme (MAST I), continued as MAST II and MAST III. FP5, FP6 and FP7 did not include specific budgets for marine research, although an *ex-post* analysis of the share of marine-related projects is available. During FP7 there was a dedicated marine call, The Ocean of Tomorrow (total budget 124 million euro in 2010-2012 and 55 million euro in 2013) which funded multidisciplinary projects addressing the great challenges for marine research (figure 3). Horizon 2020 includes marine research as a crosscutting activity (source: *EUROCEAN Marine Knowledge Gate*, *Santos et al. 2007*, *Jagot et al. 2012*).

In comparison with the total budget available in the FPs, the share of funding for marine related projects increased from approximately 1% at the start of the FPs (1987-1991) to 3.2% during FP6 (2002-2006). During FP7 (2007-2013) this 'marine share' increased to 6.1% of the total FP7 budget and represented 1,250 projects with a total budget of 2.66 billion euro. The largest share (21%) of this budget addressed the theme 'Environment' (0.56 billion euro; 111 projects) (source: *EurOcean Marine Knowledge Gate*; figure 3).

Funding of data collection and data management

In the context of the initiative Marine Knowledge 2020 (COM (2010) 461), it is estimated that the cost of the in situ collection of marine data by public institutes of the EU member states is more than 1 billion euros a year. The cost for remote sensing of the European Seas is estimated at 400 million euros per annum. Besides financing marine/

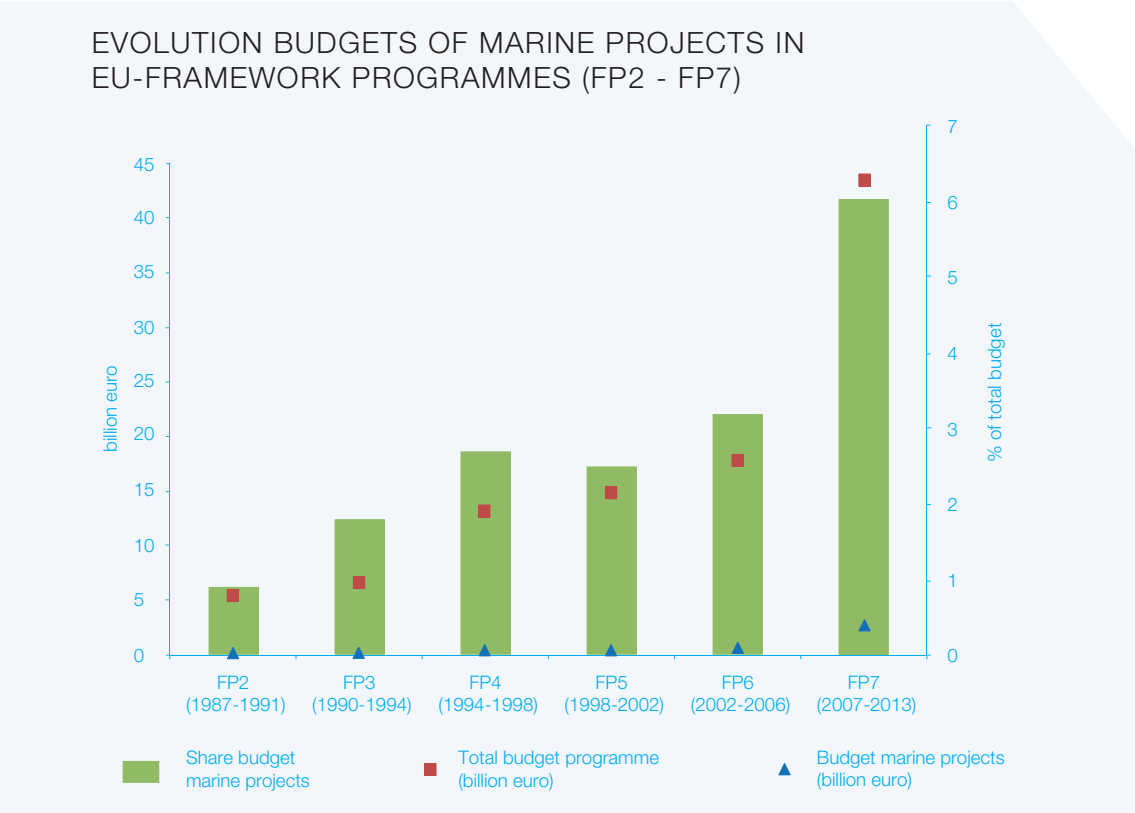

Figure 3. Marine project budgets funded by EU Framework Progammes FP2 - FP7 (billion euro) and share (%) of the total FP budgets (Source: CORDIS database, adapted by *EurOcean Marine Knowledge Gate*, data September 2015).

maritime components and initiatives in the European research programmes, an additional amount of 40 million euros is provided each year for the data collection programmes in fisheries management (DCF). A specific additional annual effort of 18.5 million euros between 2011 and 2013 focused on data collection and data integration in regional seas to support requirements of the MSFD (*COWI; Ernst&Young 2013*).

The EC increased the *EMODnet* budget within the EMFF because of the estimated benefits to be achieved by an enhanced accessibility of marine data with higher resolution, for a series of user groups. Creating additional value due to a higher efficiency in the organisation of marine observation and data management at the European scale, is an important step towards increasing cost-efficient production in science.

2. Marine research in Flanders and Belgium

2.1 Policy context for scientific research in Flanders and Belgium

DIVISION OF COMPETENCES

The division of competences for scientific research and innovation in Belgium was established in the Special law on Institutional Reforms (law of 8 August 1980). Article 6bis of this law stipulates that the federal government, the communities and the regions are responsible for scientific research within the framework of their competences, including research in pursuit of international or supranational conventions and treaties. The primary responsibility for research and innovation lies with the communities and regions. The communities are responsible for all personal matters, cultural affairs and education and training. Regional matters in the fields of economy, energy, public works, environment and transport are competences of the regions. Unlike the other regions, Flanders has chosen to join its community and regional competences (see **Flemish policy context for science and innovation**)

In the Federation Wallonia-Brussels (formerly French community), it is the *Direction de la recherche scientifique* (DGENORS) which is responsible for science policy and *inter alia* for the financing of universities. The *FNRS* is the

administration that organises the funding of research programmes, infrastructures and operations for the French-speaking universities. Since 2007-2008, the French-speaking universities in Belgium have merged into three 'Académies Universitaires', as a results of the revised subsidy regulations in this community (figure 4). *Innoviris* (formerly IWOIB) is the institute for the promotion of research and innovation for the Region of Brussels.

The federal government is responsible for: the implementation and organisation of networks for the exchange of data between scientific institutions at national and international level; space research in the framework of international or supranational institutions, agreements or instruments; federal scientific and cultural institutes; programmes and actions requiring a uniform implementation at national or international level; and for keeping a permanent inventory of the science capacity of the country. The harmonisation and coordination of the cooperation between the different levels is provided by the Interministerial Conference for Science Policy (*IMCWB*) (figure 4).

FEDERAL SCIENCE POLICY

The Federal Public Planning Service Belgian Science Policy Office (*BELSPO*) is responsible for the science policy of the federal government (figure 4).

BELSPO manages the *research programmes* in support of the policy with regard to sustainable development, actions to address climate change, biodiversity, energy, health, mobility and the information society. Of particular importance for the marine research field, is the research programme 'Belgian Research Action through Interdisciplinary Networks' (*BRAIN-be*). In addition, marine research is funded by multidisciplinary programmes such as the Interuniversitary Attraction Poles (*IUAP*). The implementation of IUAP is based on a cooperation agreement between the federal state and the communities.

In the field of biodiversity, BELSPO coordinates the services with regard to the collection of biological cultures used in scientific research (see website Belgian Coordinated Collections of Micro-organisms, *BCMM*). The *Belgian Biodiversity Platform* is the information and communication platform for scientific research on biodiversity in Belgium. BELSPO is also responsible for the Belgian contribution to the European Space Agency (*ESA*). The department consists of 10 federal scientific institutes, of which the Royal Belgian Institute for Natural Sciences (*RBINS*) and the Royal Museum for Central Africa (*RMCA*) are of particular importance with regard to marine research (figure 4).

More detail is provided on the Belgian Portal for Research and Innovation (*BRSITI*). An overview of research funded by BELSPO is available from the *FEDRA database*. The *INVENT database* keeps a permanent inventory of the Belgian research capacity (research units, research projects and research staff).

FLEMISH POLICY FRAMEWORK FOR RESEARCH AND INNOVATION

In Flanders, the Science, Technology and Innovation (EWI) policy domain is responsible for the management of science and innovation policies. In addition, other policy domains may take initiatives in the field of science and innovation to support and develop their policies (albeit to a much lesser extent). The EWI policy domain includes the EWI department, as well as several government agencies. In 2015 there was a call for restructuring. It is intended that the new structure will be in place in 2016 with the following entities:

- The Science, Technology and Innovation department (*EWI*) is responsible for the preparation, monitoring and evaluation of specific action plans, policy research and regulations in the policy fields of economics, science and innovation;
- A number of agencies are responsible for the policy implementation, including:
    - A new Agency for Innovation and Entrepreneurship (AIO), as a results of the merging of Enterprise Flanders (AO) and the business-oriented services of the Agency for Innovation by Science and Technology (IWT). The AIO will act as the front office of the Flemish government for entrepreneurs.
    - A renewed Research Foundation - Flanders (*FWO*), as a results of the merging of FWO, the Hercules Foundation (*Herculesstichting*) and the more long-term oriented programmes of IWT. FWO has the task of promoting and supporting fundamental research at the universities of the Flemish Community, including partnerships between the Flemish universities and other research institutes. The Hercules Foundation was founded by the Flemish government for the financing of medium- and large-scale infrastructures for fundamental and strategic research.

- In addition, there are investment agencies such as the Participation Company for Flanders (PMV).

- The Flemish Council for Science and Innovation (*VRWI*) is the strategic advisory board for science and innovation.

The Information Guide for Entrepreneurship and Innovation (*EWI 2015*) provides an overview of all actors in the Flemish research landscape and is available on the *website of the EWI department*.

Figure 4. Overview of the competences and the policy context for research and technological development (R&D) in Belgium, the communities and the regions (non-exhaustive overview).

SCIENCE AND INNOVATION: KEY INSTITUTES IN FLANDERS

In the first place, the research is conducted by the five universities (*KU Leuven University*, *Ghent University*, *Antwerp University*, *Vrije Universiteit Brussel*, *Hasselt University*) and Flemish university colleges (*VLHORA*), the Strategic Research Centres (SOC) (*VITO*, *IMEC*, *VIB*, *iMinds*, *Flanders Make*), the Flemish scientific institutes (*INBO*, *ILVO*, *KMSK*, *Flanders Heritage Agency*) and other research institutes (*ITG*, *KMDA*, *Botanic Garden Meise*, management schools) (figure 4). Flanders Marine Institute (*VLIZ*) is the coordination and information platform for marine research in Flanders. Flanders Hydraulics Research (*WatLab*) is a division of the technical support services of the Mobility and Public Works department of the Flemish government. An overview of the policies and authorities involved with regard to the coast and sea is provided in **Chapter 2 'Use of the sea'**.

The Flemish Interuniversity Council (*VLIR*) is an autonomous advisory platform aiming to improve the communication and cooperation between the Flemish universities. The VLIR secretariat for university development cooperation (*VLIR-UOS*) supports partnerships between Flemish universities and colleges in Flanders and the South. The Flemish university colleges are also organised in the umbrella organisation of the Flemish University Colleges (*VLHORA*). The Flemish Council for Universities and Colleges (*VLUHR*) ensures coordination between all actors involved in higher education in Flanders (VLIR, VLHORA, university associations, etc.).

MARINE RESEARCH IN FLANDERS AND BELGIUM: GENERAL POLICY CONTEXT

Marine research in Flanders and Belgium is mainly guided and funded within the framework of the science policy of the communities and the federal and regional governments (see **Divisions of competences**). Because of the growing importance of marine science in response to the societal challenges, there is an expansion of the research to other policy domains and applications as well as to a broader range of authorities. These include the fields of fisheries and aquaculture, sand and gravel extraction, dredging and dumping, shipping and ports, offshore energy, nature and environment, as well as tourism, culture and heritage. An overview of competences and authorities in the coastal zone, marine areas and adjacent estuaries is provided in **Chapter 2 'Use of the sea'**.

2.2 History of marine research in Flanders and Belgium

PIONEERS AND GROUND-BREAKING RESEARCHERS

Prior to the introduction of a more systematic approach to marine research in the early 20th century, research was conducted by scientists individually. Within this early marine research, it is *Pierre-Joseph Van Beneden* (1809-1894) who is considered as the founding father of marine sciences in Belgium. Together with his son *Edouard Van Beneden* (1846-1910), *Alphonse Renard* (1842-1903) and *Gustave Gilson* (1859-1944), he turned marine research into an essential component of sciences in Belgium. The life and work of these pioneers and groundbreaking marine scientists can be explored on the website *Wetenschatten* ('Science Treasures', a series of informative fact sheets called 'Historical personalities in Belgian marine research', VLIZ) (figure 5).

A FIRST MARINE STATION IN OSTEND

In 1843, *Pierre-Joseph Van Beneden* opened a modest laboratory called *Laboratoire des Dunes* (Dune Laboratory) on the east bank of the Ostend harbour. This marine station entirely relied on his own resources. Since other renowned European marine stations were established several years later, Van Beneden was ahead of his time. After 3 decades of research the laboratory was closed in 1870. The history of the first marine station and subsequent initiatives of *Edouard Van Beneden* and *Gustave Gilson* are described in detail in *Breyne et al. (2010)* and *VLIZ Wetenschatten 2015a*.

THE START OF THE SYSTEMATIC MARINE RESEARCH WITH AN INTERNATIONAL DIMENSION

At the turn of the century, marine science in Belgium led to several important breakthroughs. The *Antarctica expedition of the Belgica in 1897-1899* (see also *VLIZ Wetenschatten 2015b*) achieved great innovations at times when *Gustave Gilson* initiated systematic research on the North Sea. Between 1898 and 1939 he collected 14,000 marine samples, which nowadays are used as reference material for current studies in the BNS.

In 1927, the Marine Research Institute (*Zeewetenschappelijk Instituut (ZWI)*) was founded on the initiative of Gustave Gilson, with Gilson as its first director. The institute's research focus was mainly on fisheries, inventorying the fauna and flora of coastal waters, and statistical data collection of sea fisheries. Gilson was also the driving force behind the 'First International Congress of the Sea' which took place in Ostend in 1926. Together with his assistant Charles Gillis, he played a role in the establishment of the international programme for data collection for sea fisheries in the North Atlantic Region and the North Sea, through *ICES*. From 1947 onwards, Eugène Leloup was director of ZWI. The institute was closed in 1967 due to a persistent lack of financial resources (*VLIZ Wetenschatten 2015a*).

From 1963 the fisheries research performed by ZWI, was taken over by the Experimental Station for Sea Fisheries (*Proefstation voor de Zeevisserij*), later known as the National Station for Sea Fisheries (*Rijksstation voor Zeevisserij*) which is now part of the Institute for Agricultural and Fisheries Research (*Instituut voor Landbouw en Zeevisserij* (*ILVO*)) of the Flemish government. Meanwhile, several marine research groups at the Flemish universities changed their research focus towards the BNS and the Southern North Sea. In October 1970, these academic groups were at the basis of the establishment of the Institute for Marine Research (*Instituut voor Zeewetenschappelijk Onderzoek (IZWO)*). The main goals of IZWO were to support, coordinate and disclose marine research in Belgium. When IZWO was dissolved in 1999, its tasks, staff and infrastructure were assigned to the newly established Flanders Marine Institute (*VLIZ*) (*VLIZ Wetenschatten 2015a*). VLIZ is a platform for marine and coastal research in Flanders, and due to the involvement in several projects and networks, the institute supports and promotes the international visibility of Flemish marine research and international marine education.

RESEARCH PROGRAMMES FOR THE NORTH SEA

In 1970, the Belgian government initiated *Project Zee* (Project Sea) within the scope of the research programme Environment/Water. This was the *first phase of the programmatic research of the North Sea* (the former department for Programmatic Science Policy (DPWB), later DWTC, now BELSPO). Between 1971 and 1976, 200 researchers from 40 university laboratories and scientific institutes and from multiple disciplines, cooperated in the project. The goal of Project Sea was the collection of scientific data and the development of modelling techniques to simulate the impact of natural phenomena and anthropogenic effects on the marine environment. At the end of Project Sea, a unit was founded to manage the Mathematical Model of the North Sea and the Scheldt Estuary (*MUMM*), which today exists under the Operational Directorate Natural Environment (*OD Nature*) of the RBINS. Since Project Sea, there have been 7 consecutive phases in the research programme for the North Sea (see also *Pirlet et al. 2015a*, Guide to funding instruments).

RESEARCH VESSELS

As early as 1914, *Gustave Gilson* highlighted the importance of a national oceanographic research vessel. However, the introduction of the first Belgian oceanographic research vessel RV Belgica only followed a few decades later. An overview of the different Belgian marine research vessels that operated prior to the launching of the RV Belgica is presented in *Pirlet et al. (2015c)*.

It was not until 1984 that the federal research vessel *RV A962 Belgica* was introduced. The Opertional Directorate Natural Environment (RBINS) is responsible for the management of the ship and its scientific equipment, as well as the planning and organisation of the scientific campaigns at sea. The Belgian Navy provides the crew, the operational support and services from the home port of the Belgica in Zeebrugge (*website RV Belgica OD Nature*).

Between 2000 and 2012, the Flemish government provided the RV Zeeleeuw, a converted pilot boat, in support of the marine research community. In 2012 the RV Zeeleeuw was replaced by a new research ship: the *RV Simon Stevin*. The operation and crew of this ship are provided by *VLOOT*, the shipowner of the Flemish government. VLIZ coordinates the scientific programme and manages ship time as well as the research infrastructure and equipment (*website VLIZ*).

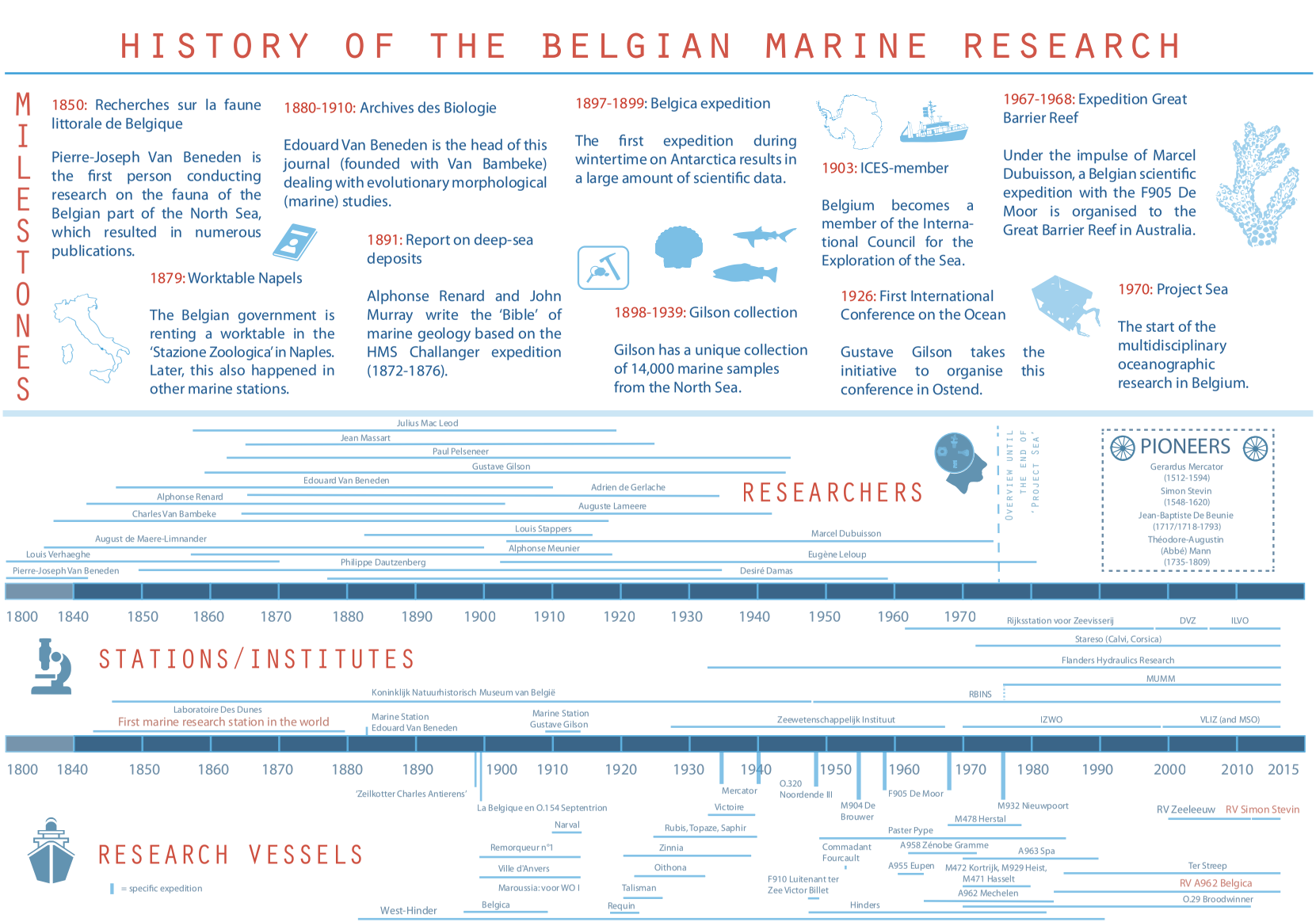

Figure 5. An overview of the history of Belgian marine research (Copyright: Scigrades – Graphical design for scientists and research institutions, torrez.pieter@gmail.com).

2.3 Marine research in Flanders and Belgium: inventory of the present research landscape

As commissioned by the Flemish government (EWI department)[1], the marine research landscape in Flanders and Belgium is mapped by VLIZ. This overview aims to make an inventory of the marine research landscape in an objective and coherent way, and provides annual updates concerning the research capacity (staff, infrastructure and resources) and knowledge output (publications and projects output). The inventory focuses on research groups affiliated with both Flemish universities and graduate schools as well as those of the Wallonia-Brussels Federation, and with Flemish and federal scientific institutes. The marine research includes the marine, maritime, coastal and/or estuarine research activities these groups perform in various research areas (*VLIZ 2014*).

METHODOLOGY

The present inventory addresses the 2008-2014 period. In order to compare and monitor evolutions in the long term, clear definitions, preconditions and replicable methods are used (*VLIZ 2014*). A crucial concept in this methodology is the definition of a Marine Research Group (MRG) (table 4).

Table 4. Definition of a Marine Research Group (MRG).

DEFINITION MARINE RESEARCH GROUP (MRG)	
An MRG simultaneously meets 4 criteria	The research group is located in Flanders or Belgium.
	The research group periodically receives government funding or subsidies embedded in policy agreements, covenants, or other legal agreements.
	Groups which do not belong to a university association are included in the list of institutes recognised for scientific research, as established in the royal decree of 22 August 2006 and the subsequent modifications of this royal decree.
	The research group focuses on marine research, or research which is relevant for this topic. In case of doubt, the measurable marine research output of the group is checked over the last 5 years. This output is defined as 'more than one peer-reviewed or VABB publication the first author of which is affiliated to the research group'.

The methodology of the inventory relies on the content of the Integrated Marine Information System (*IMIS*, VLIZ), supplemented by an annual systematic survey of literature databases. In the present inventory, these databases are Web of Science (through ISI-Web of Knowledge) and the Flemish Academic Bibliographic Database for the Social Sciences and Humanities (*VABB-SHW*). The selection of publications from these databases are checked on their marine focus and affiliation with a Belgian research group. Next, the publications are added to the collection of the Belgian Marine Bibliography (BMB) in IMIS, and a link is made between the publication, the institute and the author(s). Based on these links, new or additional MRGs are identified, provided they have published more than one marine peer-reviewed or VABB publication as a first author in the past 5 years. Since 2013, the inventory and the antecedent survey of the literature databases are conducted annually for the previous five years, on a fixed benchmark date in July. The benchmark date for the present inventory was 13 July 2015. The relationships that are established in IMIS between the publication, the institute and the author(s), allow quantitative measurement regarding the marine publications and the authors of the MRGs. However, the inventory of the staff of the MRGs is based on a direct survey of the research community. Every MRG, as well as the researchers, authors and publications affiliated with the MRG, are linked to one or more research domains and disciplines. To enable benchmarking at an international level, the definition of research domains and the further division into research disciplines, are based on the international available typology.

The conditions and the limitations associated with this methodology are described in detail in the annual report (*VLIZ 2014*). Important boundary conditions are:

- The inventory addresses MRGs at universities, graduate schools and scientific institutes in Flanders and Belgium. Marine research performed outside of these institutions is not included in the present inventory.

[1] Covenant between the Flemish Government and the Flanders Marine Institute, established by decree in Article 42 of the BS 07/28/2010.

- The results of this inventory are mainly focused on peer-reviewed publications and publications included in the Flemish Academic Bibliographic Database for the Social Sciences and Humanities (*VABB-SHW*). However, a significant part of the scientific output is available in other types of publications (e.g. theses, books, scientific advices, project reports, etc.) that are disclosed and described in IMIS, but have not yet been included in the current inventory.
- The collection of publications included in the inventory is largely determined by the surveyed databases (Web of Science and VABB-SHW), in which certain scientific fields are less represented. This implies a potential incompleteness or underestimation of the scientific output of the MRGs. In the future, the inventory may be expanded to new information sources, citable data sets and other scientific knowledge outputs (project deliverables, maps, models, etc.).
- In literature databases, new publications are included and described with a certain delay, meaning that the statistics for publications from 2014 are incomplete in the current inventory.

MARINE RESEARCH CAPACITY IN FLANDERS AND BELGIUM

Number of Marine Research Groups (MRGs)

A total of 99 MRGs were identified in Belgium on the benchmark date (July 2015). 60 groups of these MRGs are affiliated with Flemish university associations (figure 6). Scientific institutes are counted on an institute level, whereas university groups are inventoried on the level of a laboratory, unit or research group. An overview of the MRGs is available in *Mees et al. (2015)* and can also be consulted in an interactive manner on *http://www.vliz.be/en/institutes* and *www.compendiumkustenzee.be*.

The increase in the number of MRGs compared to the benchmark in 2013 (82 MRGs), can be mainly attributed to the Flemish university associations (+12 MRGs) and the universities and graduate schools of the Wallonia-Brussels Federation (+4 MRGs). These 'new' MRGs are mostly existing research groups that have recently expanded their expertise to marine research fields and applications.

The largest share of MRGs is situated in Ghent (32%) and Brussels (23%), while an important percentage of groups are also located in Liège, Antwerp and Leuven. The MRGs affiliated with scientific institutes are mainly located in Brussels and Ostend (figure 7).

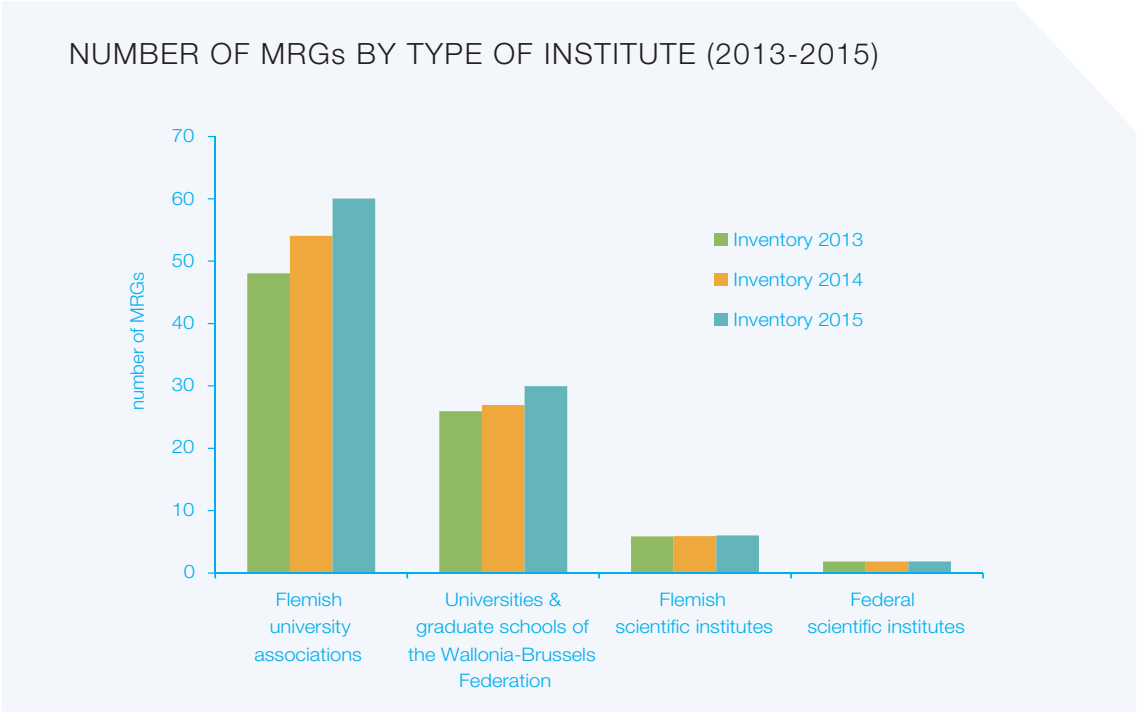

Figure 6. Number of MRGs, by type of institute (inventory 2013-2014-2015).

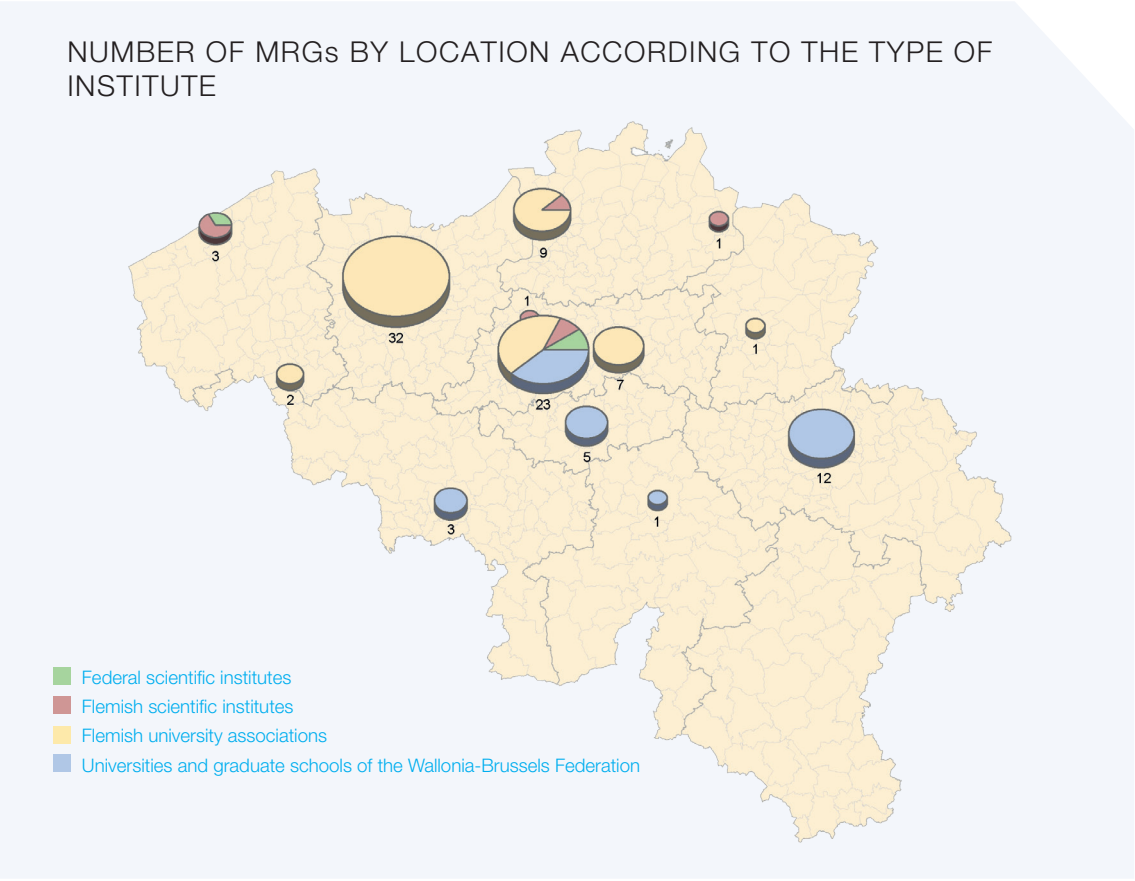

Figure 7. Number of MRGs, according to the type of institute and location (2015).

Number of marine researchers

The number of staff active in marine research provides a better insight in the actual research capacity than the number of groups. On the benchmark date of 2015, 1,373 persons were counted who were affiliated with an MRG and were active in marine research on a full- or part-time basis. This number is 30% higher compared to the benchmark of 2013 (1,075 persons). This increase is partly due to the increase in the number of groups concentrating on marine research themes, but is mainly the result of the improved response of the MRGs to the survey. The figures of 2013 can therefore be considered as an underestimation. The Flemish university associations employ 680 staff members, which represent about half of the marine research and specialised personnel in Belgium. Next in line are the Flemish scientific institutes (307 marine staff members) and the universities and graduate schools of the Wallonia-Brussels Federation (288 marine staff members), followed by the federal scientific institutes (98 marine staff members) (figure 8).

The 1,373 staff members wo are actively involved in marine research in 2015, can be further categorised in professors and heads of department (223 staff members), researchers in PhD programmes or continued research (826) and specialised, research-supporting employees (324). It should be noted that not all personnel is employed as a full-time equivalent (FTE) and/or focusses entirely on marine research topics.

Based on figures from 2013 (*Debackere & Veugelers 2015*), the Flemish MRGs (987 staff members) are responsible for 6.3% of the R&D-personnel employed in higher education and the public sector in Flanders.

The majority of the marine staff is male (63.7% versus 36.3% women). The percentage of women in marine research amounts to 46.3% in the category ‘specialised personnel’, but drops to 36.4% among marine scientist ((post)docs and PhD students) and even to 21% among heads of department and professors. For comparison: the percentage

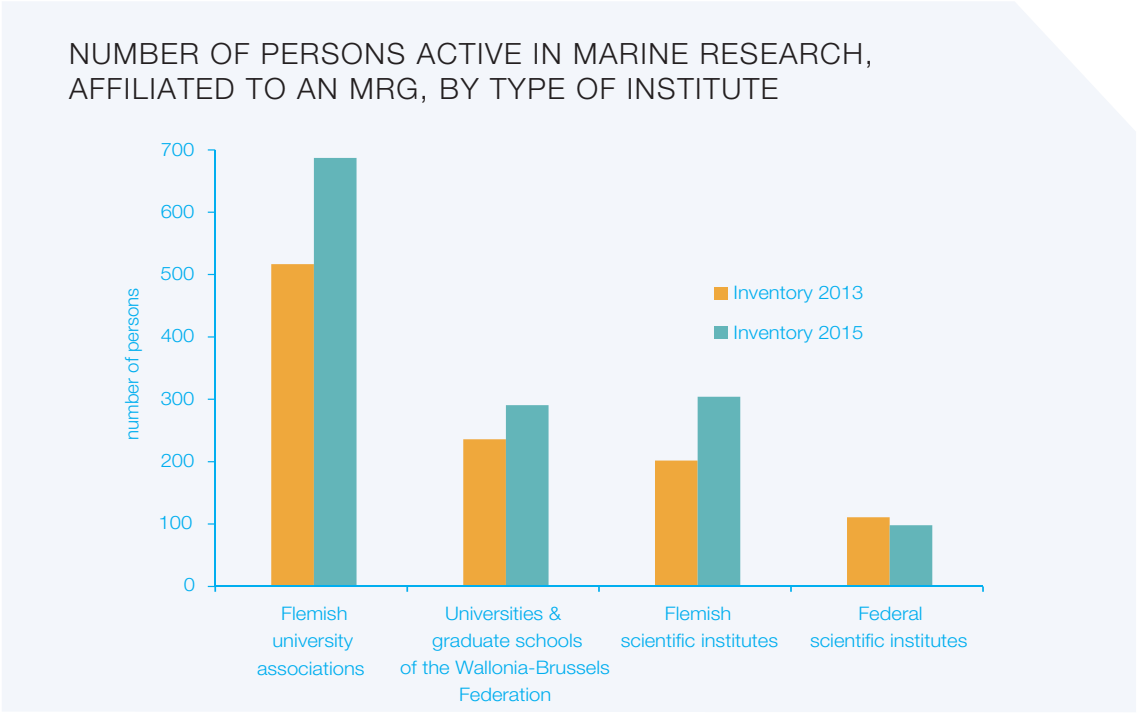

Figure 8. Number of persons active in marine research, affiliated to MRGs (2014-2015), by type of institute (Source: VLIZ survey 2014-2015).

of women active in research in higher education and the public sector in Belgium amounted to 44.6% (figures 2011[2], source: R&D statistics *Commissie Federale Samenwerking, Overleggroep CFS/STAT*). The male/female division within the Flemish universities reveals that in 2014, 60% of the assistants and 47% of the doctoral assistants were female (*Debackere & Veugelers 2015*).

The median of the number of employees active in marine research per research group (marine researchers and specialised personnel) amounts to 9 persons per MRG. Only 7 MRGs have more than 30 'marine' staff members. This mainly concerns the scientific institutes. More detailed figures about the MRGs are available in *VLIZ (2014)* (updated annually).

Marine research capacity by research domain and discipline

The bulk of the marine research at the MRGs is carried out within the research domain of natural sciences: 65 research groups out of the 99 inventoried MRGs (with 1,021 marine staff members; survey 2014-2015) focus completely or partially on biological, chemical or earth sciences. The research domains can be further divided into several research disciplines (figure 9), in which the share of biological sciences (41 MRGs, 624 marine staff members) and earth sciences (25 MRGs, 455 marine staff members) stands out. In addition, research is carried out in no less than 16 other research disciplines ranging from fisheries and aquaculture sciences (6 MRGs), civil engineering (10 MRGs), history and archaeology (5 MRGs), economics and business (4 MRGs) to law and legal studies (3 MRGs). Note that one MRG can be allocated to several disciplines.

SCIENTIFIC OUTPUT

The scientific output of MRGs is diverse and includes peer-reviewed publications, books, (project) reports, proceedings, scientific advices, theses, multimedia, etc. In the figures below, only the output that can be collected in an exhaustive way is taken into account: peer-reviewed and VABB publications. In **Chapter 2 'Use of the Sea'**,

[2] Since 2012, technicians and other personnel constitute one category in the national R&D statistics. The more recent figures (after 2011) are therefore no longer comparable.

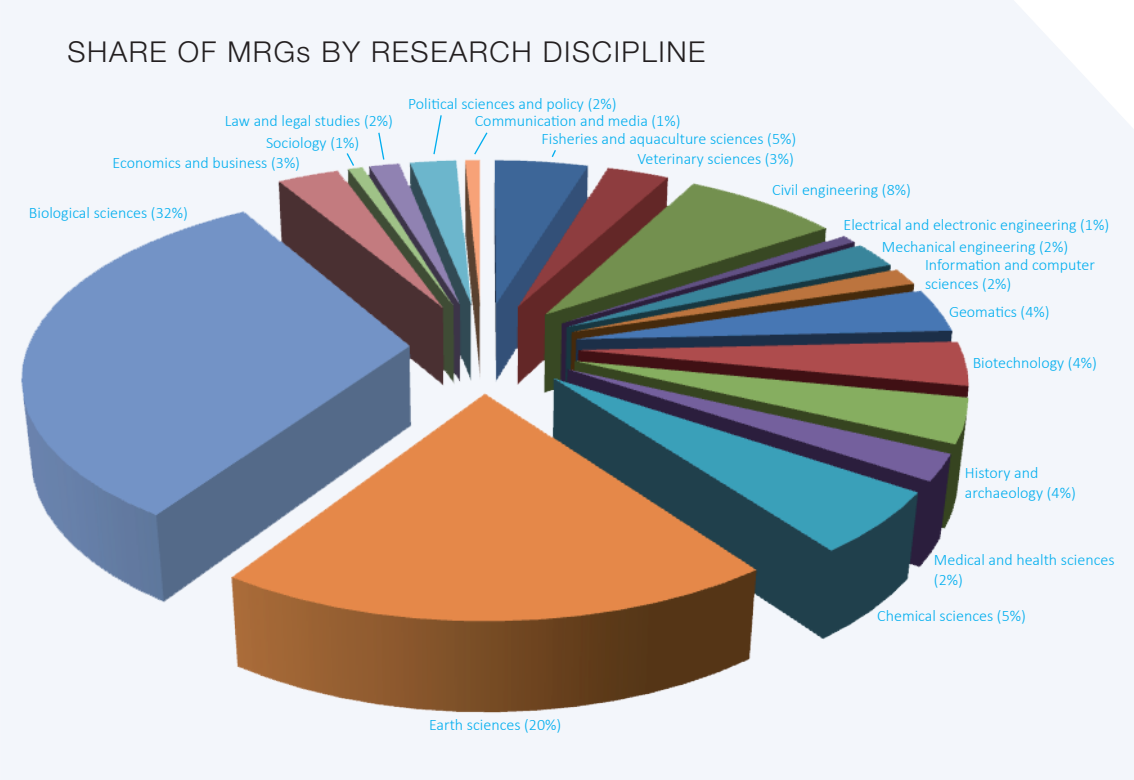

Figure 9. Share of MRGs by research discipline (2015). Note: MRGs can be allocated to several research domains and disciplines.

other types of publications are disclosed, linked with the respective themes. Hence, it is not the intention to express a value judgement about the different types of publications in this context. In the future the aim is to expand the inventory of scientific output towards other types of publications as well as to research domains that are less focused on publishing in peer-reviewed journals.

Number of marine peer-reviewed publications

Between 2008 and 2013, the Belgian MRGs published on average 432 marine peer-reviewed publications every year, with an increase of 382 publications in 2008 to 486 in 2013 (figure 10). In line with the research capacity (see above), the majority of the marine peer-reviewed publications is published at the universities (*VLIZ 2014*). In this regard, it is important to bear in mind that the scientific institutes mainly concentrate on various types of policy-supporting or policy-preparing knowledge outputs, such as advices, project reports, monitoring or evaluations of policy objectives. Hence, these institutes are less focused on publishing their research in peer-reviewed articles.

In the seven years between 2008 and 2014[3], a total of 1,698 unique authors were active (an average of 571 unique authors per year). These persons are affiliated with an MRG and act as (co-)authors of a marine peer-reviewed or VABB publication. In line with the increase in personnel of the MRGs, a gradual growth of the number of authors can be noticed during recent years. The majority of these authors were affiliated to Flemish university associations (56%) and an even larger part was working in the research domain of natural sciences (65%).

Between 2008 and 2014, the MRGs published in 721 different peer-reviewed journals with 77 publications in the most frequently used journal. Especially remarkable is the rapid increase of the share of Open Access journals from 6.2% in 2008 to 20.5% in 2014[3].

The largest share of marine peer-reviewed publications (including peer-reviewed VABB publications) is published by MRGs in the research domain of natural sciences (87%) and the domain of engineering and technology (24%) (2008-

[3] The numbers of 2014 are incomplete at present.

2014). This is in accordance with the research capacity (MRGs and staff members), but is also the result of the nature of the surveyed database (Web of Science, see **Methodology**) and the culture within the research field of natural sciences to publish in peer-reviewed journals.

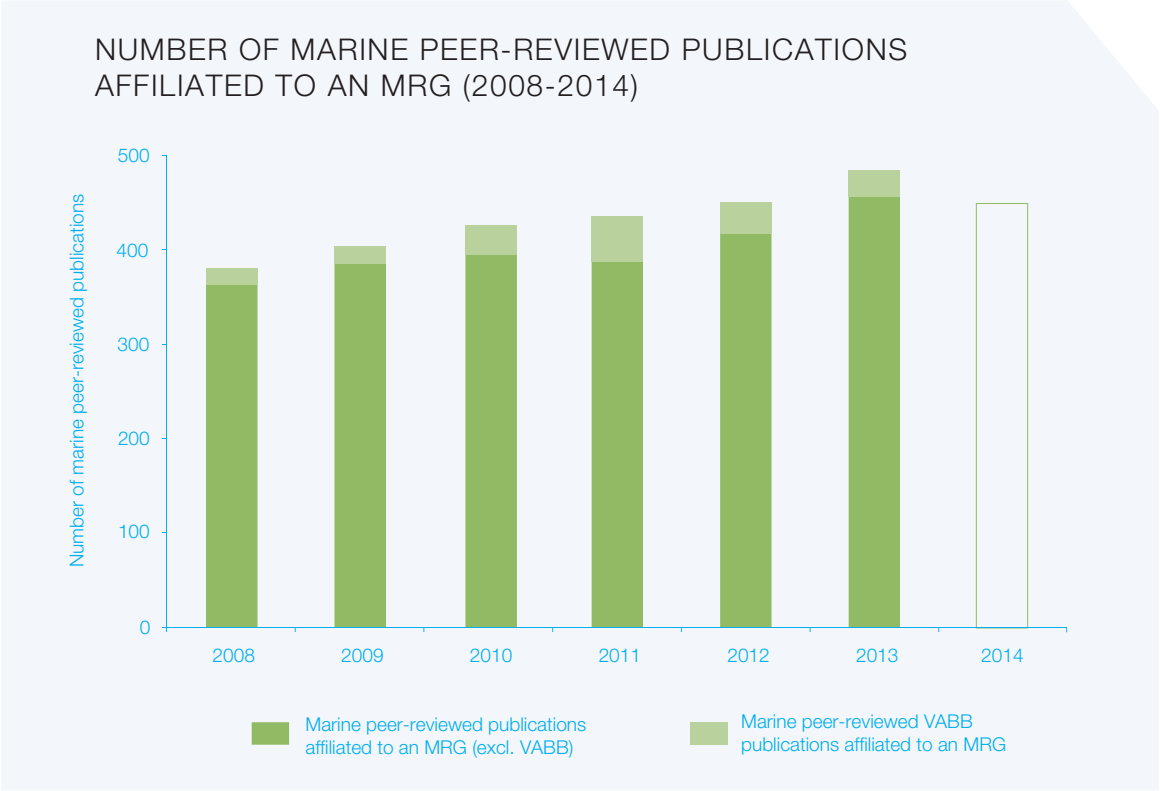

Figure 10. Number of marine peer-reviewed publications affiliated to an MRG. Note: the numbers of 2014 have a lower degree of completeness. In order to conduct a trend analysis, it is necessary to take into account a period of more than 5-10 years. It is therefore preferable to determine an average for this survey.

Relative citation indicators, peer-reviewed publications

Although relative citation indicators are no direct measure for the quality of the conducted research, they enable to benchmark according to an internationally accepted standard method. In cooperation with *ECOOM*[4], relative citation indicators were calculated for a list of 2,071 marine peer-reviewed publications affiliated to the MRGs (2008-2013). A time frame of three years was used for these citations. This means the year of publication and the two following years. For publications included in the database in 2012 and 2013, the time frame for citations was therefore not complete.

An important parameter in this context is the Relative Citation Rate (RCR), which is defined as the ratio of the Mean Observed Citation Rate (MOCR) and the Mean Expected Citation Rate (MECR) (table 5). An RCR value of more than 1 therefore means that the set of publications is cited more than can be expected based on the journals in which they have been published. For the publication list of the MRGs, the RCR is 1.16. The Normalised Mean Citation Rate (NMCR) of the publications of the MRGs also scores above the globale average with a value of 1.34. This relative indicator is defined in the same way as the RCR, but the actual impact of the citation is implicitly compared with the expectations, based on the subdomains in which these publications have appeared. These relative citation indicators show that the publications of the MRGs rate above the global average with regard to citations (figure 11 and table 5).

[4] The analysis of the relative citation inidactors was performed in collaboration with ECOOM (Bart Thijs, Wolfgang Glänzel & Koenraad Debackere, KULeuven). Analysis based on UT-codes in Web of Science.

Table 5. The relative citation indicators of the marine peer-reviewed publications of the MRGs.

RELATIVE CITATION INDICATORS	
MOCR (Mean Observed Citation Rate) = 4.27	The average number of citations per publication, calculated as the ratio of the number of observed citations in a three year time frame and the number of publications.
MECR (Mean Expected Citation Rate) = 3.69	The average number of expected citations per publication, calculated as the ratio of the number of expected citations and the number of publications.
RCR (Relative Citation Rate) = 1.16	The ratio of the MOCR and the MECR. An RCR value of more than 1 means that the set of publications is cited more than can be expected based on the journals in which they have been published. An RCR value of 1 means that the observed value corresponds exactly with the global average.
NMCR (Normalised Mean Citation Rate) = 1.34	This relative indicator is defined in the same way as the RCR, but the actual impact of the citation is implicitly compared with the expectations, based on the subdomains in which these publications have appeared.
NMCR/RCR = 1.16	This indicator reveals to what extent the citation impact of the journals, in which the publications appeared, is in accordance with the field standard. An indicator value of less/more than 1 therefore means that the set of publications on average appeared in journals with a lower/higher impact than can be expected based on the fields to which the publication belongs.

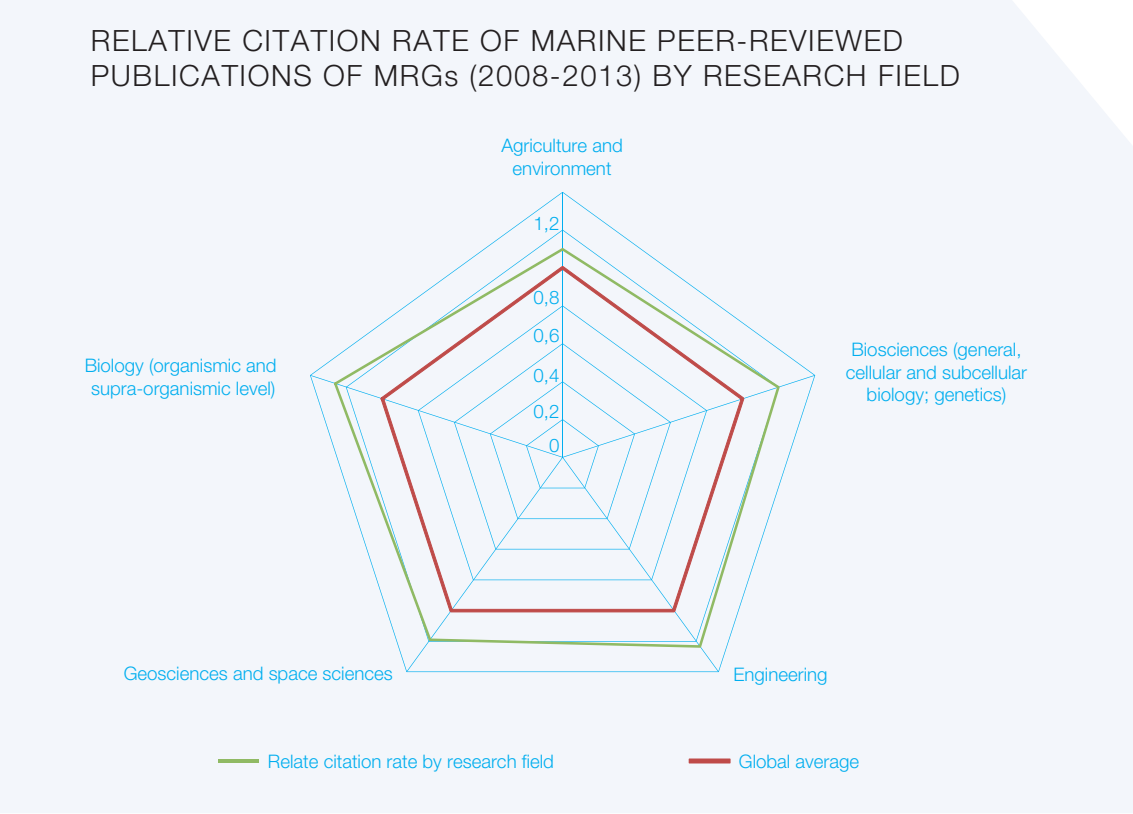

Figure 11. The Relative Citation Rate (RCR) according to the research domain to which the marine publications of the MRGs belong in Web of Science. Only domains containing more than 100 publications for the concerned period (2008-2013) have been included in the analysis.

Geographical study areas of the marine research, based on the peer-reviewed publications

A detailed analysis of the study area of the publications (2008-2010-2012-2013) reveals the international character of the research performed by the MRGs. The percentage of publications (in which study areas are included) that can be considered part of the international research amounts to 74.8% (figure 12). The remaining 25.2% can be considered as regional research and includes the Belgian part of the North Sea, the Belgian coastal zone (beach, dunes and coastal polders), the Scheldt Estuary and the Southern Bight of the North Sea. 6.5% of the publications specifically

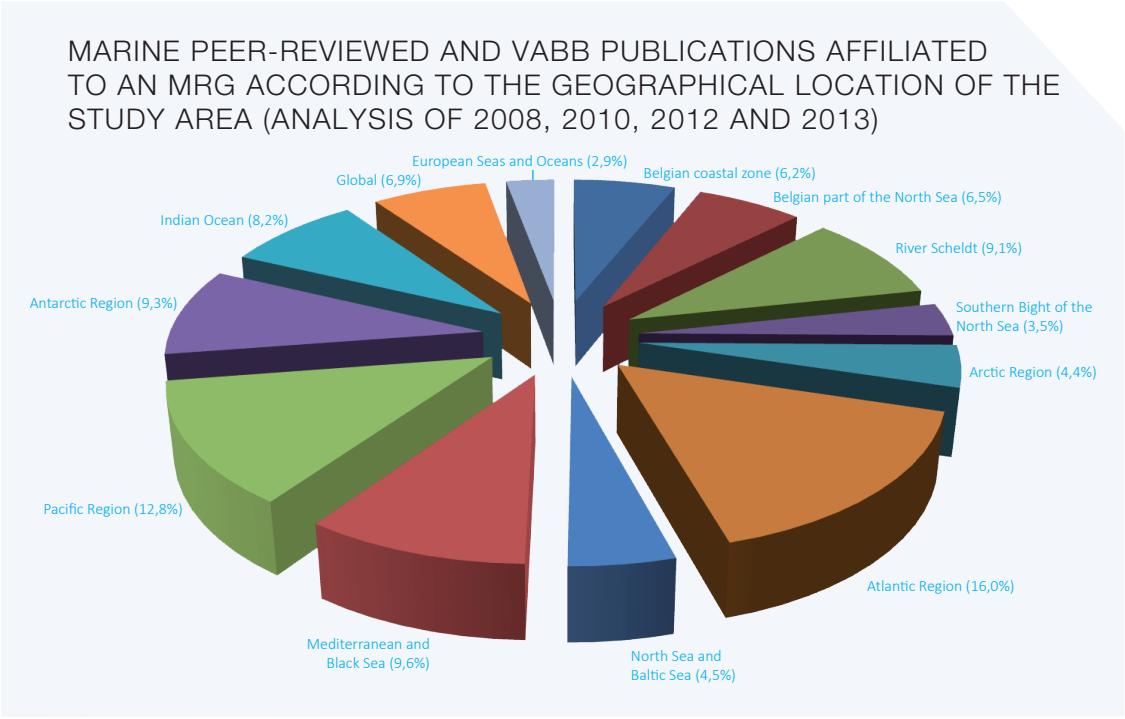

Figure 12. Marine peer-reviewed and VABB publications affiliated to an MRG, according to the geographical of the study area, analysis based on the years 2008, 2010, 2012 and 2013. A publication is always assigned to one geographical area, unless multiple areas are explicitly mentioned.

focus on research in the BNS. In this context, it is important to bear in mind that part of the scientific knowledge about the BNS is published in types of publication that are not part of this analysis, or are not publicly available. The relative importance of the various geographical study areas remains relatively stable throughout the analysed period. For a certain part of the publications (39.3%), it was not possible or not relevant to indicate a geographical study area.

Collaboration between MRGs, according to peer-reviewed publications

Between 2008 and 2014, on average 30% of the peer-reviewed and VABB publications resulted from a collaboration between at least two MRGs. Although the cooperation for these joint publications mainly occurred between MRGs within the research domain of natural sciences (25.0%), 9.3% and 3.3% of the co-publications were also the result of collaborations between natural sciences and, respectively, the domain of engineering and technology and the domain of agricultural and veterinary sciences. The aforementioned figures are, to a large extent, a consequence of the research capacity in the different types of institutes and research domains (for detailed figures, see *VLIZ 2014*).

The collaborations mainly occurred between MRGs affiliated with universities, both within the language regions (Flanders: 12.2%, Wallonia-Brussels Federation: 6,4%) and across the language border (5.0%) (2008-2014). Additionally, a significant number of publications resulted from the cooperation of MRGs at Flemish universities with federal (6.0%) and Flemish scientific institutes (5.1%).

These figures only reflect the collaboration concerning marine research with regard to the peer-reviewed and VABB publications. In addition, there is also a range of partnerships in projects, education, monitoring, etc. which do not necessarily result in joint peer-reviewed publications.

International collaboration, according to peer-reviewed publications

With regard to international cooperation, 73.1% of the examined publications from 2013 resulted from the collaboration with at least one foreign author (originating from 70 different countries). This means that the MRGs score higher than the average Belgian and Flemish percentage regarding international peer-reviewed co-publications, which amounted

to 66.2% and 64.9% respectively in 2013 (*Debackere & Veugelers 2015*)[5]. The Belgian MRGs mainly collaborated with the neighbouring countries: France, the Netherlands, the UK and Germany. The USA is an important partner as well with regard to joint publications (see further, figure 23). The Belgian MRGs act as first author in on average 50.2% of the international co-publications[6].

Use of research vessels, according to peer-reviewed publications

For at least 21.5% of the marine peer-reviewed and VABB publications of the MRGs in 2013, a research vessel was used for sampling or data collection (34.7% in 2010). In 33% of these publications, the research vessel was specifically mentioned by name. It concerns a total of 31 different research vessels, originating from 14 different countries, with the RV Belgica, RV Polarstern, RV Zeeleeuw and RV Pelagia as the most frequently mentioned vessels. These publications constitute the sea-going research of the MRGs. The other publications mainly concern coastal and estuarine research, modelling studies, experimental research in laboratories, social and economic studies, historical research, etc. An unknown share of the aforementioned publications, however, indirectly relies on sea-going research (e.g. for the validation of models or experiments).

2.4 Funding of marine research

In addition to the regular operational funds, MRGs at university associations and scientific institutes have several instruments at their disposal for the funding of marine research. Depending on the type of research and the research objectives, different funding sources are available on both a Flemish, federal and European level (*Pirlet et al 2015a*, Guide to funding instruments). Unlike most of its neighbouring countries, Belgium does not dispose of programmatic funding or a dedicated budget line for marine research. Hence, no figures exist concerning the (evolution of) funding of this type of research. However, with the exception of some initiatives like the Ocean of Tomorrow-call in FP7, other funding instruments also lack earmarked marine budgets. Therefore, the sources and databases for project funding can not be directly surveyed with regard to the budget for marine research. The selection of projects with MRGs as project partners makes it possible to systematically map the funding of marine research in MRGs, comparable to the inventory of the research capacity, infrastructure and output.

The inventory of the funding is based on the individual project participations and project resources, for the different funding instruments that were surveyed (FWO, IWT, VLIR-UOS, BELSPO, FP7, Horizon 2020 and EFRD). However, the inventory does not provide an exhaustive representation of the available budgets for marine research in Flanders and Belgium, as not all instruments were screened and some limitations are in place for a number of the surveyed funding instruments.

This inventory focusses on research projects and resources with the following characteristics:

- Funding based on competitive resources and specific/special grants;
- Used for marine research;
- Granted to MRGs in Flanders and Belgium;
- Granted in the period 2008-2014, according to the year of allocation;
- Funding instrument focused on R&D, on a Flemish, federal and European level.

A definition and breakdown of the types of research are presented in *Soete (2012)* and *VRWI advice 114 (2007)*. The methodology for the survey of the funding channels, the detailed figures, the preconditions and the limitations which are taken into account, are available in a detailed report (*VLIZ 2015*).

FUNDING OF MARINE RESEARCH - FLANDERS

The inventory reveals that the Flemish MRGs received an average annual subsidy of 10.7 million euros between 2008 and 2014, from competitive resources financed by the Flemish government (FWO, IWT and VLIR-UOS). On top of that, an annual subsidy of on average 2.6 million euros is granted for the support and coordination of the marine research (research vessel RV Simon Stevin, VLIZ, science communication). In order to finance its international engagements concerning marine research and data management, the Flemish government provides an additional 1.8 million euros per year (IODE Project Office IOC-UNESCO, EMODnet Project Office, JPI Oceans, Flanders-UNESCO

[5] By way of comparison: the average share of international co-publications in 2000 amounted to 48.8% for Flanders and 50.3% for Belgium.
[6] Average for the years 2008-2010-2012-2013: counted as the percentage of publications with at least one foreign author; each country is only counted once per publication.

Science Trust Fund (FUST)). Since 2013, the Hercules Foundation contributes another 2 million euros per year for the *ESFRI* research infrastructures which are relevant for the marine research community (*ICOS*, *LifeWatch*, *EMBRC*). Hence, the targeted Flemish public funding resources for marine research amount to 17.1 million euros per year.

In addition, the MRGs have access to important public resources for the direct funding of research organised in academic institutes (Special Research Fund (BOF), Industrial Research Fund (IOF), etc.). The annual operational and investment funds of the Flemish scientific institutes and strategic research centres (SOC), account for a part of the budget which is dedicated for personnel and resources for marine research and monitoring. Budgets for (policy related) research and monitoring are provided by the policy domains of Science, Technology and Innovation (EWI), Environment, Nature and Energy (LNE), Mobility and Public Works (MOW), Foreign Affairs (IA), Agriculture and Fisheries (LV), etc. Additional public resources are provided for valorisation-oriented research (e.g. IOF, *TETRA-funds* for technological research at graduate schools (IWT), etc.). Information on these last resources is fragmented and/or not publicly available and is therefore not quantified in this inventory.

As a partner of VLIZ, the Province of West Flanders provides a fixed annual subsidy of 0.15 million euros to support marine research.

Research Foundation Flanders (FWO)

The Research Foundation Flanders (*FWO*) finances fundamental scientific research at universities through PhD fellowships, post-PhD research, temporary and fixed fellows, grants to scientists for research projects, participations in congresses and symposia, as well as to knowledge exchange networks and excellence programmes (such as the Methusalem and Odysseus programmes).

Marine FWO projects

Between 2008 and 2014, a total of 82 marine projects with promotors affiliated to MRGs were funded by FWO. The total budget of these marine projects amounted to 17.3 million euros (2008-2014), with an annual average of 2.5

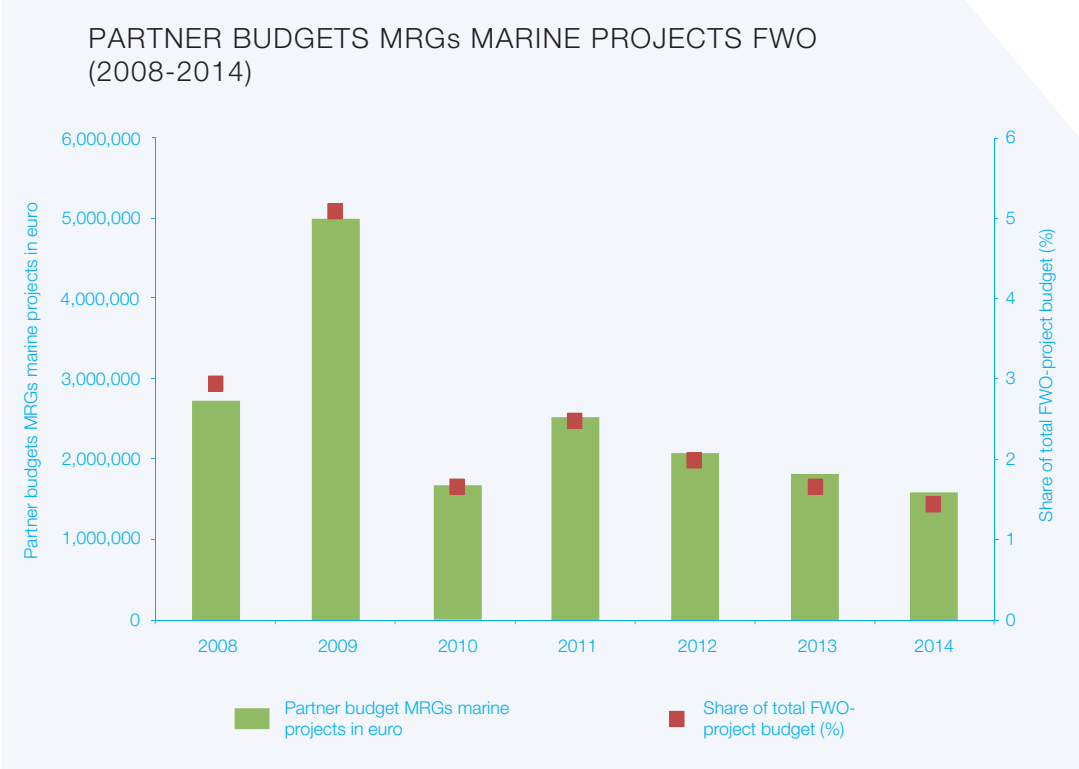

Figure 13. Marine FWO projects: partner budgets of MRGs (euros) and share (%) of the total budget for FWO projects, according to the year of allocation (Source: FWO and FWO expenditure analysis 2005-2014, processed by VLIZ).

million euros (figure 13). This 'marine share' corresponds to an average of 2.4% of the total budget for FWO projects between 2008 and 2014 (according to the year of allocation). In 2009, a significantly higher budget was granted to marine research projects compared to the rest of the analysed period. This variation can be explained by the limited number of marine projects. Hence, in order to perform a trend analysis, the collection of data over a longer period of time is necessary.

Marine FWO fellows

Between 2008 and 2014, a total of 124 marine fellows affiliated to MRGs were funded by FWO. The total budget for the funding of these marine fellows amounted to 18.2 million euros (2008-2014), with an annual average of 2.6 million euros (figure 14). This 'marine share' corresponds to an average of 1.1% of the total budget for FWO fellows between 2008 and 2014 (according to the year of allocation). In 2009 and 2013, this share was slightly higher compared to the average of the examined period.

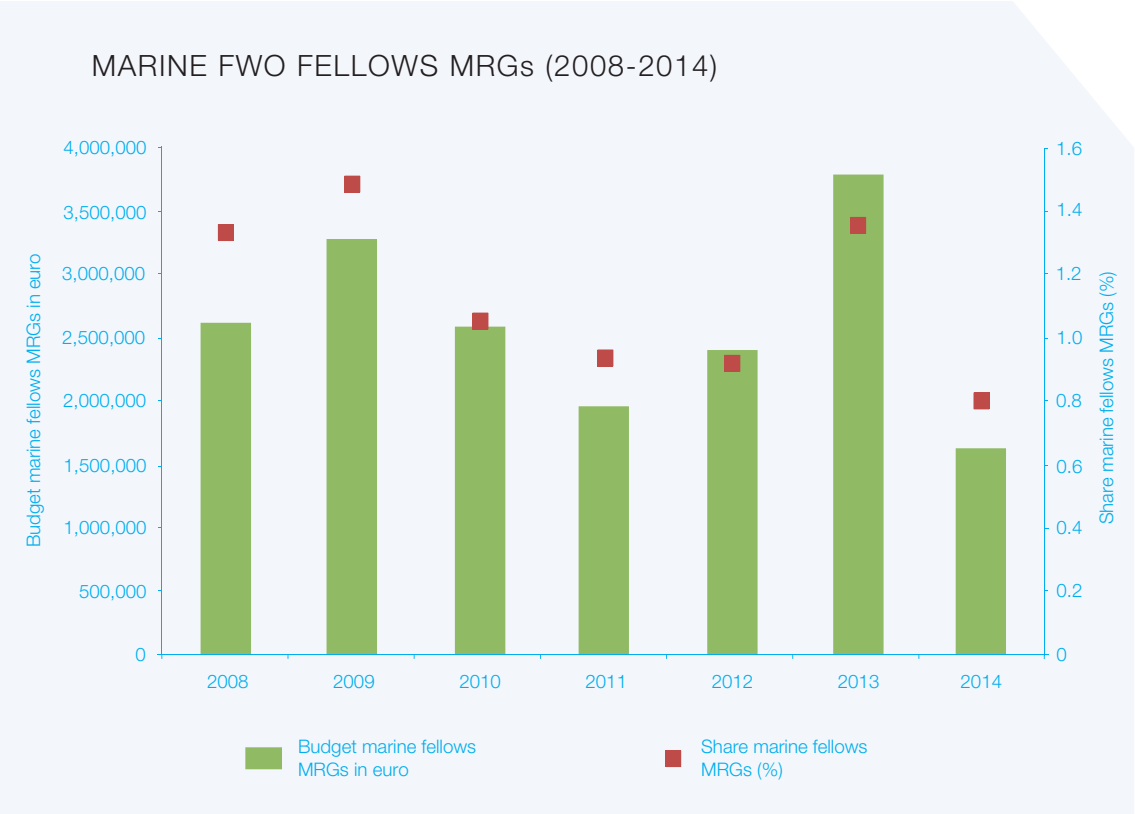

Figure 14. Marine FWO fellows affiliated to MRGs: subsidies for MRGs (euros) and share (%) of unique fellows (2008-2014), according to the year of allocation (Source: FWO and FWO expenditure analysis 2005-2014, processed by VLIZ). Note: the share (%) of the budget for marine fellows concerns an indirect estimate based on the number of fellows and an average subsidy per fellow.

Agency for Innovation by Science and Technology (IWT)

IWT focuses on specialised scholarships and on projects.

Marine IWT projects

Between 2008 and 2014, IWT financed a total of 51 marine projects (total budget of 27.9 million euros). In 23 of these marine projects an MRG was involved, representing a total budget of 24.3 million euros. The IWT budget granted to these marine projects with MRG involvement corresponds to an annual average of 3.5 million euros and an average

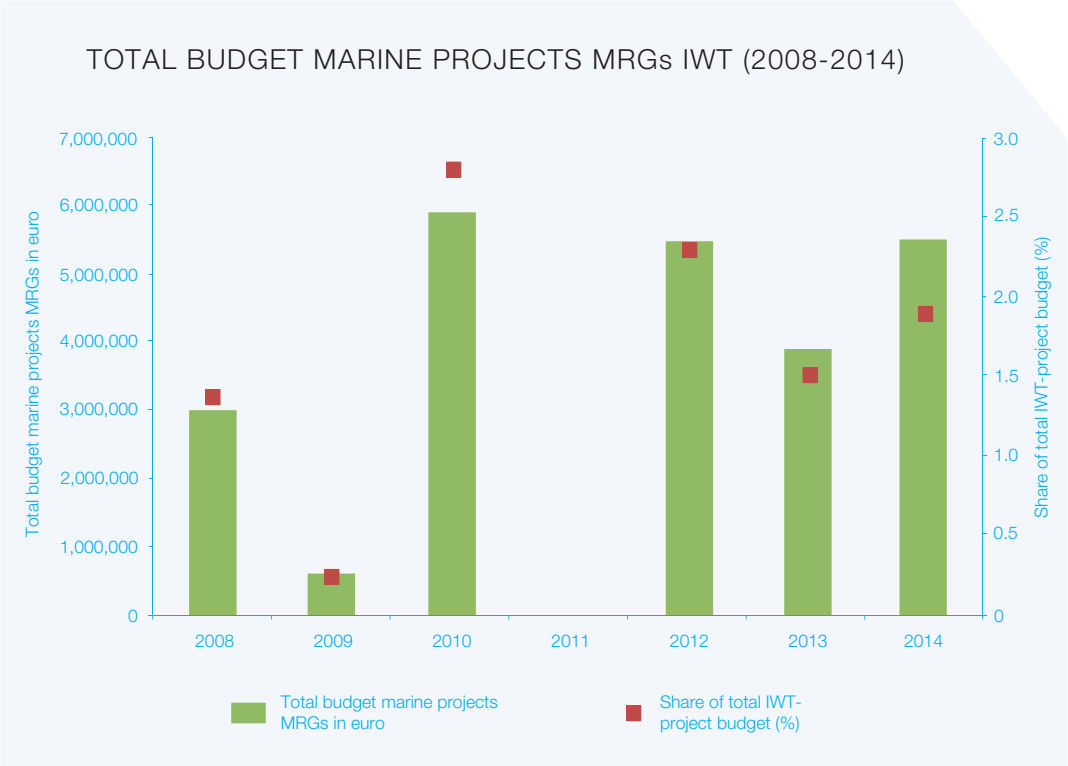

Figure 15. Total budget (euros) of marine IWT projects with MRG participation (2008-2014) and share (%) of the total IWT budget (projects), according to the year of allocation (Source: IWT, processed by VLIZ). Note: Unlike other funding channels, which were analysed on the level of individual partner budgets, the budgets for IWT projects refer to the total project budgets, which results in an overestimation of the subsidies for the MRGs.

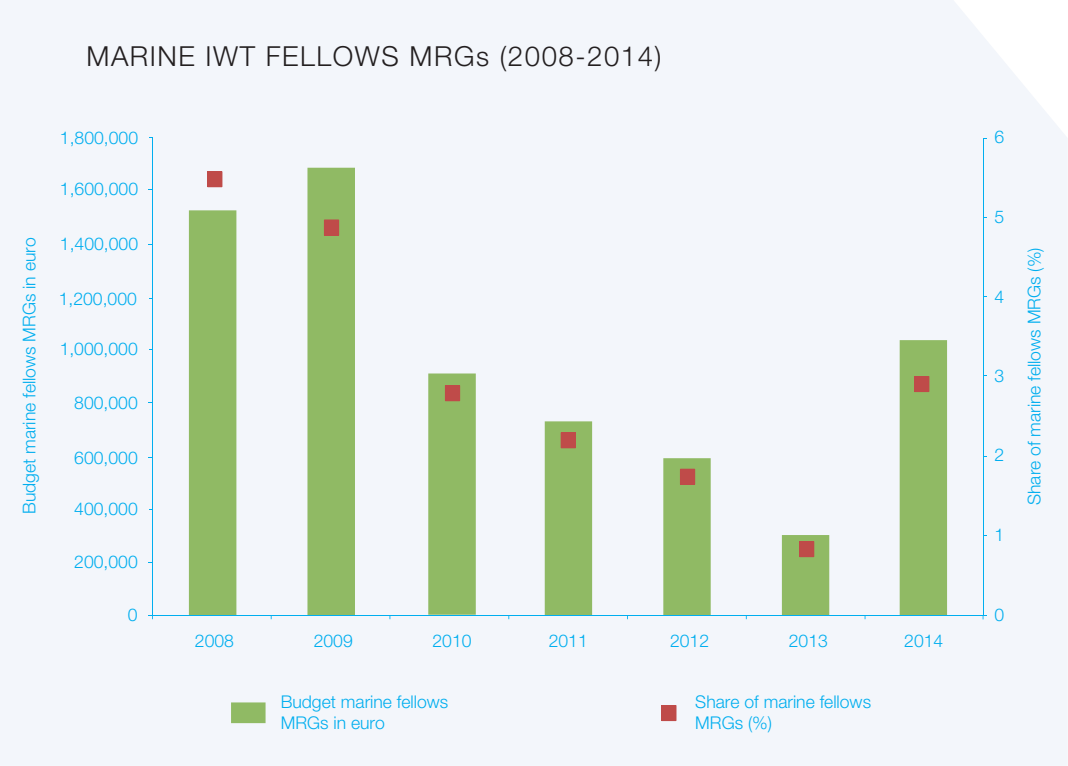

Figure 16. Marine IWT fellows MRGs: budget (euros) and share (%) of 'marine' fellows (2008-2014), according to the year of allocation (Source: IWT, processed by VLIZ).

percentage of 1.7% of the total IWT budget for projects (2008-2014) (figure 15). It is however important to point out that this analysis is based on the total project budgets and consequently results in an overestimation of the subsidies for the MRGs.

IWT fellows

With regard to the IWT fellows, a total of 46 grants were allocated between 2008 and 2014 to marine fellows which are affiliated to an MRG. These fellows represent a total budget of 6.8 million euros (2008-2014) and an annual average of 1.0 million euros. The number of granted marine fellows decreased from 11 in 2008 (1.5 million euros) to 2 (0.3 million euros) in 2013. This decrease is also observed in the share of the marine fellows of MRGs in the total IWT budget for fellows: from 5.4% in 2008 to 0.8% in 2013 (figure 16). The recent increase in 2014 brings the average percentage of marine fellows between 2008 and 2014 to 2.9%.

Flemish Interuniversity Council (VLIR)

The VLIR secretariat for university development cooperation (*VLIR-UOS*) finances projects to strengthen the higher education in the South and the internationalisation of higher education in Flanders. Between 2008 and 2014, a total of 54 marine projects with promotors affiliated to MRGs were funded by VLIR-UOS. The largest number of partnerships were established in Kenya, Tanzania and Vietnam. The total budget of these marine projects amounted to 7.9 million euros (2008-2014) with an annual average of 1.1 million euros (figure 17). This 'marine share' corresponds to an average of 3.3% of the total budget of VLIR-UOS between 2008 and 2014. It is however important to point out that this analysis is based on the total project budgets and consequently results in an overestimation of the subsidies for the MRGs.

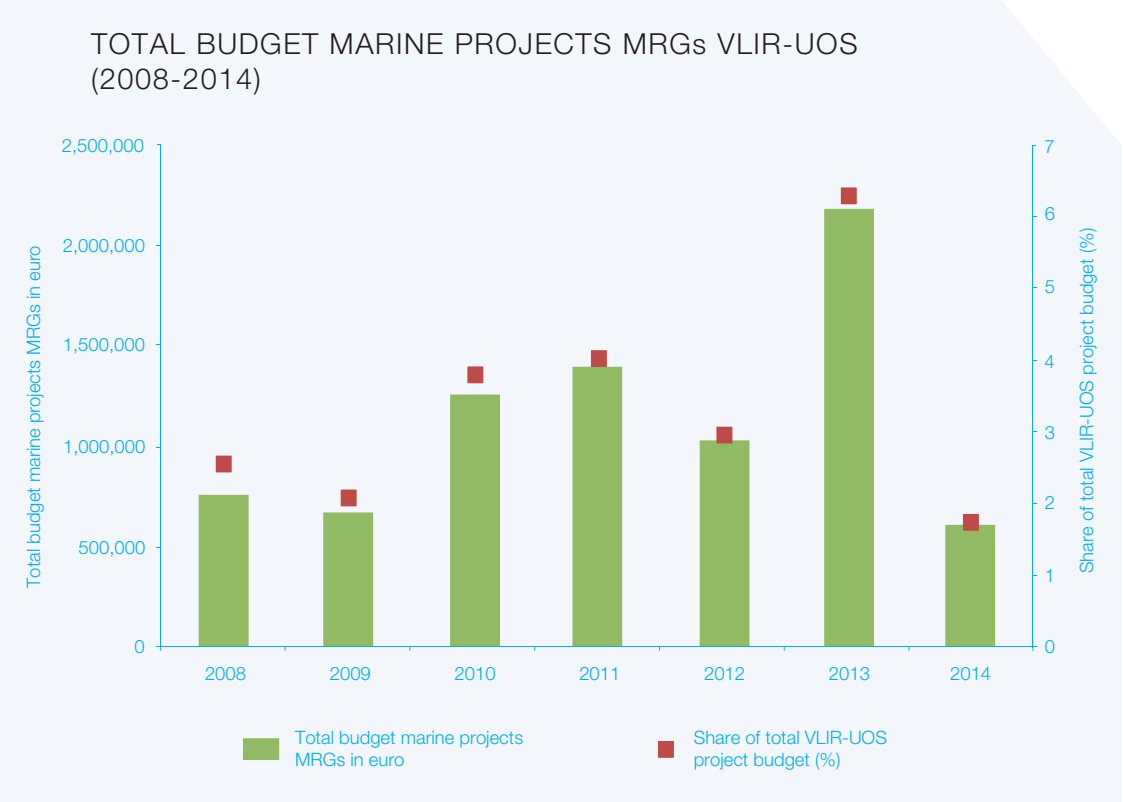

Figure 17. Marine VLIR-UOS projects with an MRG-participation: total budget (euros) and share (%) of the total VLIR-UOS budget (2008-2014), according to the year of allocation (Source: VLIR-UOS, processed by VLIZ). Note: Unlike other funding channels, which were analysed on the level of individual partner budgets, the budgets for VLIR-UOS projects refer to the total project budgets, which results in an overestimation of the subsidies for the MRGs.

Special Research Fund (BOF)

BOF is an important funding channel for stimulating academic research in Flanders. The BOF resources include calls for fellows, grants, scholarships and initiatives such as Methusalem, which are attributed according to the regulations stipulated by the EWI department (Flemish government). The allocation of BOF resources is based on scholarly results and the academic publication output. Aiming at a qualitative policy, part of the BOF resources have been attributed based on the publication and citation output (with a weighing factor of up to 35%) from 2003 onwards. At present, there are no official figures about the specific funding of marine research with BOF resources. A rough estimate of the total BOF resources awarded to MRGs amounts to 3 million euros per year. This estimation is based on the figures which were made available for a limited number of promotors associated with MRGs. These figures were extrapolated to the total number of staff members of the MRGs associated with Flemish universities.

Hercules Foundation

The *Hercules Foundation* is a funding channel of the Flemish government for investments in medium-scale and large-scale research infrastructure for both fundamental and strategic research. An online *inventory* is available for all funded projects since the beginning of the programme (2007). Since 2013, the Hercules Foundation annually provides 2 million euros for ESFRI research infrastructures (*ICOS*, *LifeWatch* and *EMBRC*).

FUNDING OF MARINE RESEARCH - FEDERAL

The PPS Belgian Science Policy (*BELSPO*) provides the operational and investment resources of the federal scientific institutes such as the Royal Belgian Institute of Natural Sciences (*RBINS*) and the Royal Museum for Central Africa (*RMCA*). Additionally, BELSPO manages competitive resources to support the marine research of the MRGs which amount to an annual average of 3 million euros (Belgian Research Action through Interdisciplinary Networks (*BRAIN-be*), Interuniversity Attraction Poles (*IUAP*)). Furthermore, BELSPO attributes 2.5 million euros a year for the operational costs of the RV Belgica and 0.1 million euros a year for *JPI Oceans*. The federal government also provides additional resources for research and monitoring in the Belgian part of the North Sea through the federal public services. The Marine Environment department (DMM) of the FPS Public Health, Safety of the Food Chain and Environment finances specific assignments and public tenders for marine research amounting to an annual average of 0.1 million (Source: DMM, processed by VLIZ 2015). Other public services are also relevant for marine research themes, such as FPS Economy, SMEs, Self-employed and Energy, FPS Mobility and Transport, FPS Finance, FPS Interior, Ministry of Defence and the Federal Police.

Between 2008 and 2014, BELSPO funded 38 marine projects with promotors affiliated to MRGs. The total marine project budgets (including BRAIN-be) amounted to 14.5 million euros, or an annual average of 2 million (figure 18). Since the start of BRAIN-be in 2012, the programme funded a total of 14 marine projects equalling a total budget of about 10 million euros. MRGs participated in 11 of the 14 projects for a total budget of 7,697,900 euros. The proportion of marine projects with MRG participation represents 14% of the total BRAIN-be budget (figure 18).

In addition, BRAIN-be finances the participation of RBINS in the JPI Oceans pilot action on deep-sea mining (0.3 million euros).

IUAP (Phase VI and VII) funded 2 marine projects between 2008 and 2014, both with participation of an MRG, with a total budget of 3 million euros (annual average of 0.4 million euros). The share of marine projects with MRG participation within IAP amounts to 1.6%. The current 'marine' IUAP project (Phase VII) focuses on ecotoxicological research for aquaculture applications. During Phase VI, research was conducted on the modelling of natural and anthropogenic processes on the hydrodynamics of the Scheldt Estuary and the interactions with the North Sea.

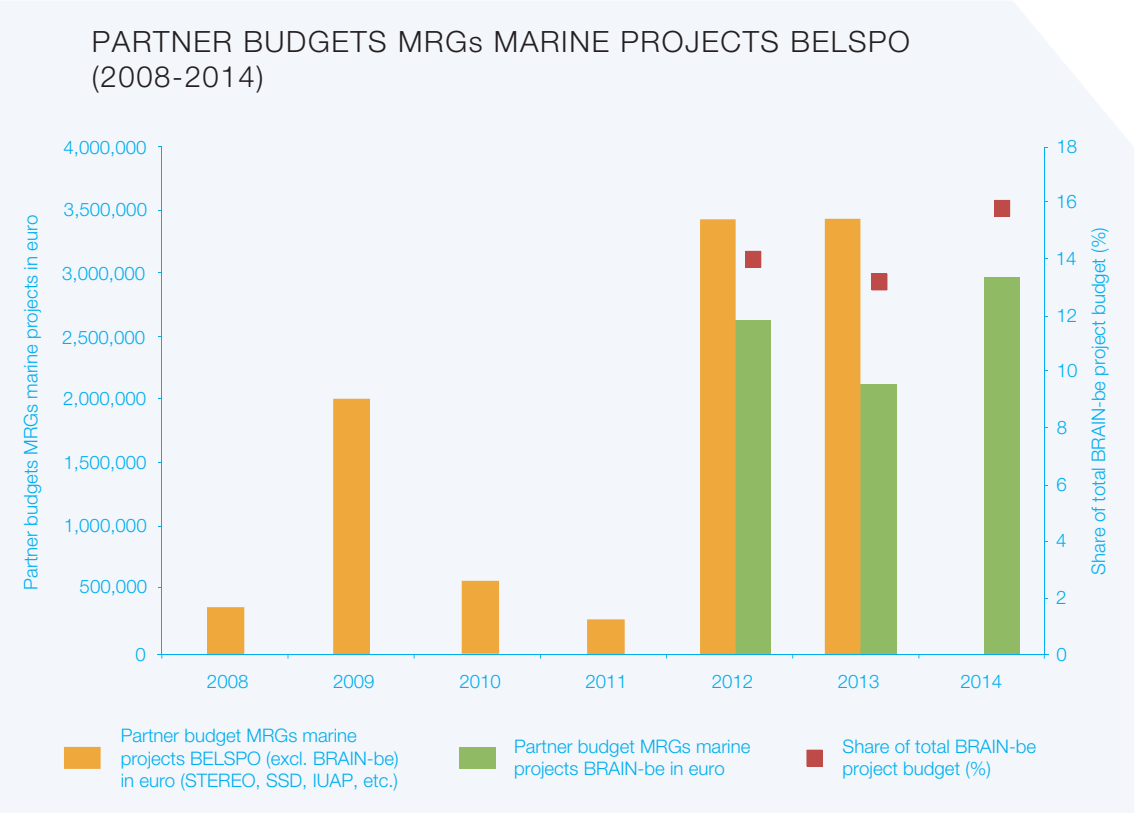

Figure 18: Marine BELSPO projects with participation of MRGs between 2008-2014: BRAIN-be (2012-2014) and other (STEREO, SSD, etc.), according to the year of allocation. For BRAIN-be, both the MRG partner budgets (euros) and the share (%) of the total BRAIN-be budget are mentioned (2012-2014) (Source: BELSPO, processed by VLIZ).

BELGIAN MARINE RESEARCH IN A EUROPEAN CONTEXT

The Belgian MRGs acquire on average about 4.7 million euros per year from European competitive funds, such as FP7, H2020 and ERDF. Additionally, MRGs also pursue several funding channels for marine research or the support of expert networks (EUROCORES, ESA, COST, European Fisheries Fund (EFF), tenders in the framework of the integrated maritime policy (IMP-grants), etc.).

From FP5 to Ocean of Tomorrow (FP7)

Europe is an important player in the steering of the marine research agenda. Despite the fact that marine research in Flanders and Belgium is mainly funded on a national level by fixed and competitive resources, an increasing share of the resources originates from international and European funding mechanisms.

In the period prior to the seventh Framework Programme (FP7), about 130 European marine projects, in which at least one Belgian knowledge institute participated, were financed by programmes such as FP6, COST, EUREKA, EUROCORES, INTERREG III, etc. (Source: EurOcean 2012). During FP6, investments in marine research amounted to 600 million euros (DG R&I 2012[7]). One of the priorities in FP6 was the transnational cooperation in project consortia. Belgian knowledge institutes (not only MRGs) participated in 101 FP6 projects, of which the Belgian partners coordinated 21 projects, corresponding with a total project budget of 32.19 million euros (Source: detailed analyses by EurOcean 2012). This is a significant increase compared to the period prior to FP6, during which Belgian institutes participated in only 31 marine research and innovation projects, mainly funded by MAST III and strategic programmes of the Directorate-General Environment (*DG ENV*). By way of comparison: during FP6, the UK had the

[7] No detailed analyses are available for other EU programmes regarding the investments in marine research during this period.

highest participation rate with 282 marine projects, while France managed the highest FP6 budgets (166.29 million euros) (EurOcean 2012). Belgium participated in 3 of the largest EU FP6 projects in the field of marine research[8].

During FP7 (2007-2013), Belgian partners (including companies and international partners with headquarters in Belgium) participated in 178 marine projects corresponding with a total partner budget of 38 million euros. MRGs participated in 71 unique projects (91 participations) with a total partner budget of 22.1 million euros or an annual average of 3.2 million euros between 2008 and 2014 (figure 19). The involved MRGs were mainly affiliated with Flemish universities (57 projects; total partner budget of 14.1 million euros). The annual variability (figure 19) is mainly caused by the timing and the type of the calls for project proposals.

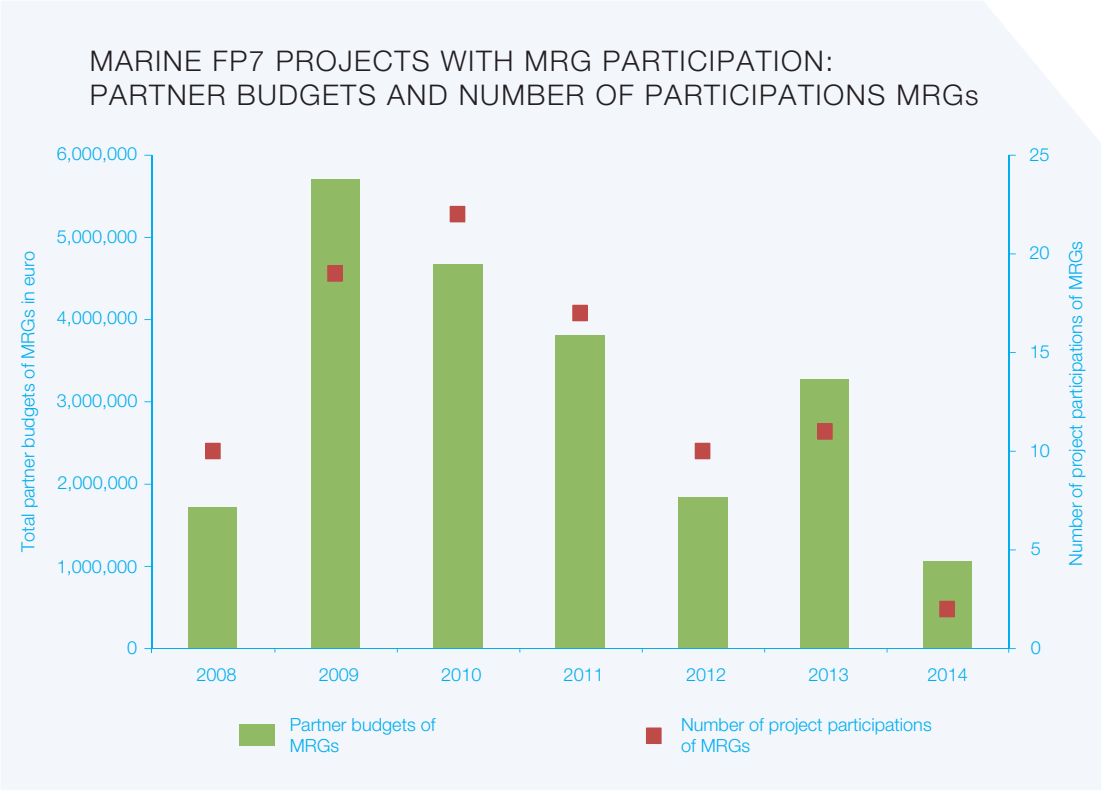

Figure 19. Marine FP7 projects with MRG participation: partner budgets (euros) and number of participations (2008-2014), according to the year of allocation (Source: EWI 2015, processed by VLIZ).

Multidisciplinary research in Ocean of Tomorrow

Marine research was funded in various kinds of thematic programmes and priorities within FP7. An important initiative for marine research within FP7, was the interdisciplinary call for marine research in Ocean of Tomorrow (FP7-OCEAN). With Ocean of Tomorrow, the EC aimed for a multidisciplinary approach and collaboration between scientific disciplines and economic sectors in order to provide innovative solutions for important marine challenges. An important aspect in this regard was the possibility for companies (including SMEs) to participate. Ocean of Tomorrow included 31 projects for a total EU contribution of 195.6 million euros (2010-2013). Belgian partners participated in 16 projects equalling a total project budget of 127.5 million euros.

Ocean of Tomorrow was an important opportunity for the internationalisation of marine research of the Belgian MRGs: in no less than 10 of the 31 Ocean of Tomorrow projects an MRG was involved (total project budget of 70.3 million euros) which corresponds with a total partner budget of 3 million euros (see table 6 for an overview of the research that was conducted within these 10 projects).

[8] DAMOCLES (16 million euros, participation of the International Polar Foundation – IPF) for the development of models and observation capacities for long-term studies in the Arctic environment; ENSEMBLES (15 million euros, participation of the Université Catholique Louvain – UCL) regarding the forecast of climatic changes and the associated effects; HERMES (15 million euros, participation of Ghent University – UGent) focusing on deep-sea ecosystems in European seas.

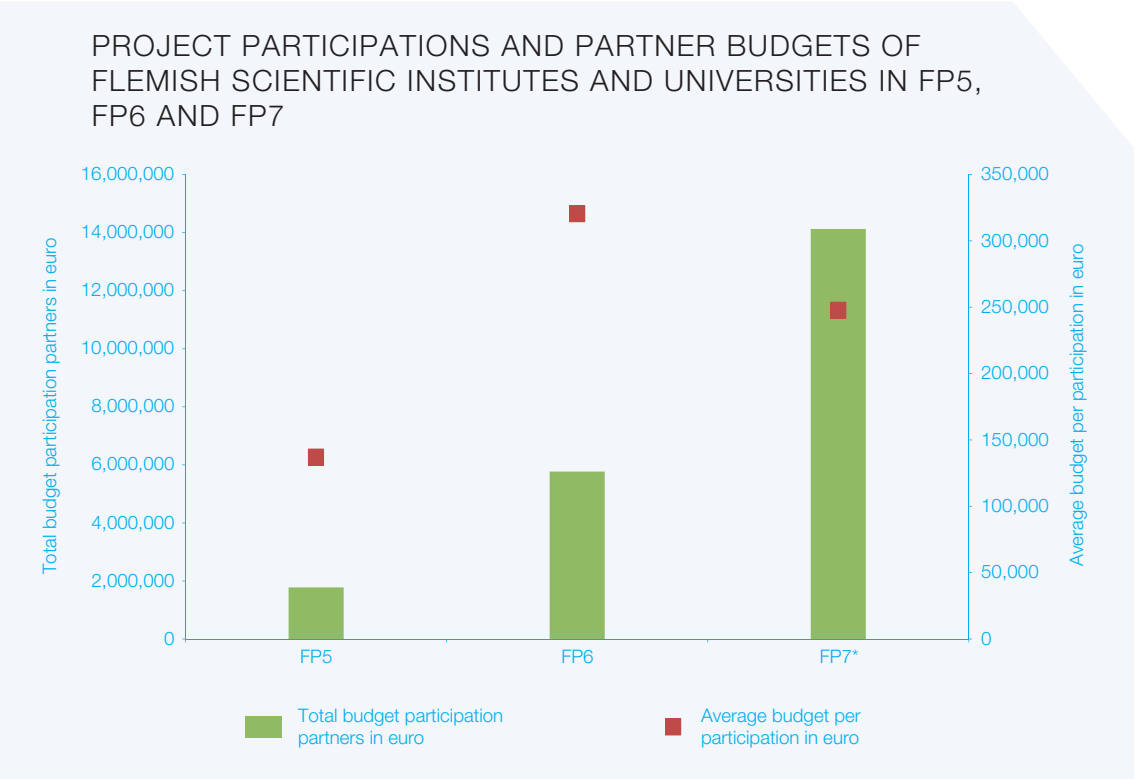

Figure 20. Marine research FP5-FP7: project participations and partner budgets of Flemish scientific institutes and universities. Note: The figures of FP7 refer to the participation of Flemish MRGs according to the definition of the inventory. The figures of FP5 and FP6 refer to the participation of Flemish universities and scientific institutes, since no definition for MRGs is available during this period.

The participation rate of Flemish marine knowledge institutes in FPs shows a continuous increase, both in the number of project participations (13 in FP5 up to 57 in FP7) and the partner budgets (1.7 up to 14.1 million euros). The average partner budgets for each project decreased in FP7 in comparison to FP6 (figure 20).

Horizon 2020

7 marine projects with MRG participation were identified within *Horizon 2020* (MyOcean, C-Cascades, EU-PolarNet, SeaChange, COLUMBUS, ALFF, SubCULTron), corresponding with a total partner budget of 1.8 million euros (6 unique MRGs and 8 participations). Horizon 2020 is still in its initial phase and the current analysis focused on the period January 2014 until April 2015. Therefore, a relative comparison of the marine projects and their respective budgets is not deemed useful at the moment.

European Fund for Regional Development (EFRD)

Additional to the above-mentioned funding instruments, research is also financed through the European Fund for Regional Development (*EFRD*). EFRD is a structural fund aiming at the realisation of the European 2020 Strategy which focuses on sustainable economic development and employment. Enterprise Flanders (*AO*) manages the Flemish EFRD programme and is responsible for the coordination and follow up of the 4 cross-border, 2 transnational and 3 interregional programmes in which Flanders participates. Over the period 2008-2014, a total of 15 marine projects, with a promotor affiliated to an MRG, were financed by INTERREG-ERFD. Those 15 marine projects correspond with 17 project participations of MRGs (10 unique MRGs) equalling a total budget (sum of individual partner budgets) of 3.9 million euros (annual average of 0.5 million euros).

Table 6. Overview of the 10 Ocean of Tomorrow projects with MRG participation.

PROJECT	KNOWLEDGE OUTPUT	PARTNER BUDGET MRGs
ECO2	• CO_2 sub-seabed storage to implement EC directive on the geological storage of CO_2 (2009) • Multidisciplinary research on the impact of sub-seabed CO_2 storage on marine ecosystems	200,000 euro
MERMAID	• Concepts for the next generation of offshore platforms which can be used for multiple purposes, including energy extraction, aquaculture and platform related transport • Guidelines to assist offshore industries in plan, establish and operate their business in the most optimal way possible • Case studies in 4 EU regional seas	220,078 euro
PERSEUS	• An effective and innovative research governance framework, to turn back the tide on marine life degradation in the southern European seas • Merge natural and socio-economic sciences to predict the long-term effects of pressures on marine ecosystems	170,000 euro
AquaTrace	• Sustainable aquaculture through improved competitiveness and environmentally-friendly production • Collective effort of research institutions and aquaculture industry across EU • Development of sustainable EU aquaculture and achievement of the 'Good Environmental Status' (GES) in the MSFD	407,516 euro
MICRO B3	• Novel bioinformatics tools to enhance EU optimal use of big data to develop marine ecosystems' biology and biotechnology • Long-lasting interoperable structures and resources for data mining: from sampling to storage, analysis and downstream use of environmental and bioinformatics • Increased understanding of marine microbial ecosystems	279,253 euro
BENTHIS	• Mitigation of adverse effects of bottom-trawl fisheries • Innovations for a 'green fishing technology' • Multidisciplinary research on the impact of sub-seabed CO_2 storage on marine ecosystems • Fishing/seabed habitat risk assessment method applied in regional seas	210,389 euro
CleanSea	• Protocols and tools for marine litter research • Innovation and business opportunities for industry and SMEs • Leadership in marine litter monitoring and remediation	159,782 euro
ECsafeSEAFOOD	• New detection tools for safe and high quality seafood • Monitoring of non-regulated chemical contaminants, risk assessment, toxicity, links between contaminants in the environment and that in seafood, effect of climate changes • Societal impacts in the sustainability of the sea food sector	561,614 euro
KILL-SPILL	• Economically and environmentally viable biotechnological solutions and tools for oil spill remediation and clean-up market • Biosensors to monitor hydrocarbon degradation, novel environmentally friendly dispersants and adsorbents, combined microbial and additives formulations, multifunctional bioremediation agents and tools for sediments decontamination	644,343 euro
BYEFOULING	• Full production line for high volume production of low toxic and environmentally friendly antifouling coatings for mobile and stationary maritime applications • Procedures, guidelines and fabrication tools for short time to market for new coating concepts • New antifouling coatings with enhanced performance	351,900 euro

European Cooperation in Science and Technology (COST)

COST supports the coordination of pan-European research networks (COST actions). The research itself is funded through other (national or regional) channels (FWO for Flanders). In the period 1971-2013, 26 marine COST actions with a Belgian partnership were financed. 13 actions were situated in the period 2008-2014, including at least 16 individual project participations of MRGs. Because of its particular structure, COST funding can not be analysed in a similar way as other projects. Therefore, the identification of individual partner budgets is not possible.

Information about the earlier FPs and the current Horizon 2020 is available through the Community Research and Development Information Service (*CORDIS website*). An overview of the European funding instruments, including the programmes of the Directorate-Generals of the European Commission, is available in the Guide to funding instruments (*Pirlet et al. 2015a*).

2.5 Challenges and opportunities for marine research in Flanders and Belgium

The policy with regard to economic development and innovation in Flanders is centered around its greatest asset: science and technology-based knowledge (*Muyters 2014*, *Coalition Agreement of the Flemish Government 2014-2019*, *Muyters 2015*). Science and innovation are key to the necessary transformation of the industrial fabric. This policy also emphasises the role of scientific research and scientific institutions in order to address the current and future societal challenges (*VRWI-Memorandum 2014-2019*). Given the societal importance and economic potential of the seas and oceans, there is a significant role for marine research in answering these needs and challenges. The marine science community in Flanders and Belgium has responded by jointly subscribing the common European vision, as well as by means of the Ostend Declaration (*McDonough & Calewaert 2010*), Navigating the Future IV (*European Marine Board 2013*) and the Rome Declaration (*European Marine Board 2014*). These vision documents emphasise an ecosystem approach as a basic requirement for a sustainable maritime economy and highlight the role of marine research and innovation in achieving European leadership in this field.

The characteristics and strengths of the marine research in Flanders and Belgium (*VLIZ 2014*) were screened by an expert panel of marine scientists (April 2015) in the context of the current societal challenges and with a view on the opportunities ahead. The panel was composed of 40 directors of Belgian MRGs and representatives from the Flemish and federal science administration. Below, some of the topics which were adressed by this panel have been laid out for further discussion:

MARINE RESEARCH: DIVERSITY AND QUALITY ARE KEY

The MRGs in Flanders and Belgium have a leading position in the EU and globally. Unlike many of the neighbouring countries, Belgium does not have a fully dedicated national marine research institute or a marine research programme to coordinate the existing capacity and expertise[9]. In terms of research capacity (personnel), the marine research landscape in Flanders and Belgium is comparable to that of the larger marine institutes in neighbouring countries (*Herman et al. 2013*). Also in terms of scientific output, measured as the annual number of marine peer-reviewed publications (figure 21), the joint scientific output of MRGs in Flanders and Belgium is comparable to that of the larger foreign marine research institutes[10].

The Relative Citation Frequency (RCR) of the marine peer-reviewed publications demonstrates that MRGs in Flanders and Belgium perform above the global standard. This also applies to the citation indicators for each of the individual disciplines (figure 11, see **Inventory of marine research**) (ECOOM). Despite the limited size of the research community and with the wide range of expertise that is covered, the Belgian marine research community has gained a reputation at the EU and global level as a result of the high quality of published research.

The high impact of the publications of Belgian marine researchers is also confirmed by international studies (Council of Canadian Academies 2013)[11].

[9] Since 1976, RBINS has a unit, the Operational Directorate of Natural Environment (OD Nature) which combines both the research in the BNS, science-policy support, and monitoring tasks. Since October 1999, the Flanders Marine Institute (VLIZ) provides a coordination and information platform for marine scientific research.
[10] Note: the specific tasks and mandates of research institutes (advice, monitoring and evaluation of policy objectives, teaching assignments) determine the extent to which researchers can be dedicated to effective research assignments.
[11] Ocean Science in Canada: meeting the challenge, seizing the opportunity. 2013. Council of Canadian Academics. Based on Scopus database analysis for 2003-2011.

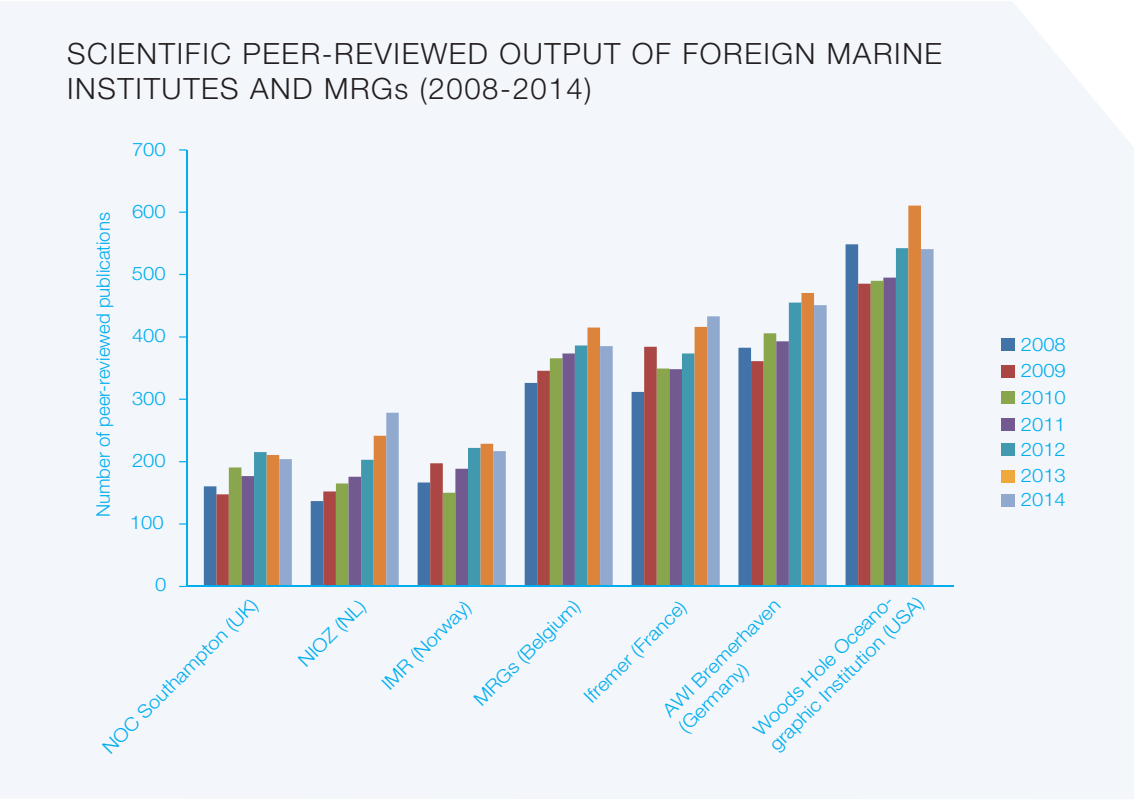

Figure 21: Scientific output of foreign marine research institutes and a comparison with the scientific output of the MRGs in Flanders and Belgium: number of marine peer-reviewed publications 2008-2014. This comparison is based on a query via the 'affiliation search' module in the Scopus literature database. The inventory of the marine peer-reviewed publications of the MRGs for 2014 has a lower degree of completeness. For a trend analysis, measurements over a longer period are necessary.

The Open Access movement makes rapid progress in marine research as well: the share of publications in Open Access journals increased from 6.2% in 2008 to 20.5% in 2014 (see **Inventory of marine research**). This open access culture has measurable effects on the integration and availability of scientific output and thus stimulates creation of new knowledge (*EC MEMO/11/891*, *Muyters 2014*).

Research capacity and expertise in a variety of research disciplines

Despite its limited coastline, the marine science community in Flanders and Belgium consists of aproximately 1,400 marine scientists and specialised staff (see **Inventory of marine research**, *VLIZ 2014*). This expertise is fragmented over 99 MRGs associated with Flemish, French and federal research institutions (see **Inventory of marine research**). Although the emphasis of the marine research is on the biological and earth sciences, the research is conducted in a wide range of disciplines. This diversity in expertise is a strong asset when tackling complex issues (impact of climate change, food security, biodiversity conservation, etc.) where multi- and interdisciplinary research is a necessity. The MRGs have an established expertise, particularly in the areas that were put forward in the Communication on a European Strategy for Marine and Maritime Research (COM (2008) 534), and in the agenda for innovation in the Blue Economy as the challenges for future research (COM (2014) 254, *European Marine Board 2013*).

The inventory of marine research reflects the dynamic character of the organisation of marine research, which is necessary to quickly respond to emerging topics both in fundamental and applied research. The expertise of the MRGs is in line with the major challenges for current and future research in the fields of: fisheries and innovative aquaculture systems, engineering and coastal protection, climate, marine biotechnology, offshore engineering and materials, maritime law, offshore renewable energy technologies, maritime transport, public health in relation to seas and oceans, and sustainable extraction of raw materials from the deep sea (see Brochure marine research in Belgium, *Mees et al. 2015*). This knowledge is valued in international partnerships with both industry and research, as well as in collaborations between research institutes.

Fundamental and applied research as a knowledge base

The leading position of the marine research in Flanders and Belgium is the result of efforts over the past years. In order to sustain this position, it is necessary to continue to invest in this knowledge base[12]. In the current dynamic setting of the marine research landscape, the access to a stable and dedicated research budget is a key issue for marine researchers. The latter is a prerequisite to be able to move from existing research towards new and innovative applications. Fundamental research establishes the necessary knowledge to understand and evaluate marine ecosystems and processes. Furthermore, this kind of research has the potential to lead to new applications, and innovation opportunities in the context of the Blue Economy in the medium or long term. The development of fundamental knowledge on marine ecosystems and their functioning is considered the basis for a sustainable use of oceans and seas. Therefore, balanced budgets should be made available to support both applied and fundamental research.

A continuous need for a coordination platform in a fragmented and complex landscape

The marine research expertise is dispersed in Flemish, French and federal research institutes (see **Inventory of marine research**). Although indicators of the degree of inter- and multidisciplinary research are currently lacking, an analysis of the publications and projects suggests that long term multidisciplinary cooperation takes place between the MRGs from Flemish and French-speaking universities, as well as with research institutes across Belgium. The multidisciplinary approach to research is needed to address the major societal challenges with regard to the seas and oceans.

Since 1999, VLIZ acts as a coordination and information platform for marine research in Flanders. The institute facilitates cooperation and networking by improving access to scientific data and information for researchers, administration and policy-makers, and through the transfer of marine knowledge to certain user groups. Furthermore, VLIZ maps the expertise of MRGs in Flanders and Belgium and supports networking both in international and national initiatives.

Programmatic research as a lever for international and multidisciplinary collaboration

The inventory of marine research funding (see **Inventory of marine research**) suggests a reduction or at least a stagnation in financial resources for marine research. In terms of EU research funding, there is a tendency towards supporting fewer, yet larger projects or consortia (in number of partners and budget) (figure 19). In the past, core funding for marine research was secured at the national level through the multi-annual research programme 'Project Sea' (1970) and the subsequent phases of the North Sea research programme (BELSPO, see **Inventory of marine research**). Project Sea also marked the start of multidisciplinary and collaborative marine research in Belgium. Such a programmatic approach may stimulate the research with regard to the grand challenges and acts as a lever to strengthen the participation of the MRGs in the international and European consortia that address these research challenges (*VRWI 2010*). The analysis of marine research output suggests that investments in marine research infrastructure (research vessels, collections, etc.) and the utilisation thereof are an important factor for international cooperation in marine research. The current restructuring of the Flemish administrations for science and innovation (FWO, IWT, the Hercules Foundation, AO) provides new opportunities for the further development of a coordinated marine research programme. In this regard, a more active cooperation between research partners and the private sector is crucial.

Careers for (young) marine researchers

Thanks to the efforts of the Flemish government (through IWT and FWO) and fiscal measures (Maribel Plan, Pegasus, etc.), an increase is observed in the overall number of PhD students (pre- and postdoctoral) in Flanders since 2000 (*Debackere & Veugelers 2015*). However, this increase in government spending is currently not reflected in the number of PhD students on marine research topics (see FWO and IWT fellows, **Funding of marine research**). This is

[12] Following the Barcelona objective, the Pact 2020 reflects the long-term vision of the Flemish government to spend 3% of its GDRP to R&D activities, by 2020. Flanders scores above the EU 28 average with 2.54 % (ECOOM, 2015) but is below the level of the leading countries (*VRWI Memorandum 2014 to 2019*). Based on a ratio of 1/3 public and 2/3 private funding, the goal of achieving the 1% level for public R&D investments will be reached when a growth path is used with an annual increase of 150 million euro on average from 2015 till 2020 (*VRWI Memorandum 2014 to 2019*, *Speurgids Ondernemen & Innoveren*, *EWI 2015*).

of particular importance as early stages of new research themes (emerging topics) are usually studied by PhD fellows at the universities and scientific institutes.

Continued efforts are needed to provide early career scientists with sufficient prospects of a career after completion of a (post-) doctoral mandate, in which they can further develop and apply their expertise. Besides an academic career, an improved flow of marine researchers and highly skilled personnel to the non-academic world allows to optimise the valorisation of marine expertise in innovation and business applications. Tax policies (e.g. tax exemptions for R&D activities to hire expertise at the level of master and bachelor degrees, tax deductions for the training of highly-qualified personnel, etc.) are proposed by the industry and SMEs to boost this process (VOKA 2015)[13].

VALORISATION OF MARINE RESEARCH IN THE KNOWLEDGE SOCIETY

Integrated research and science-based policy

An estimated 25 to 30% of the marine research in Belgium focuses on the Flemish coast, the Scheldt Estuary, the BNS and the southern North Sea[14]. These regional studies can rely on well-developed research infrastructures (research vessels, a marine station, a network of buoys and measuring systems, mathematical models, etc.). The BNS is one of the best studied marine areas in the world featuring a high data density, data quality and long term data series in a geographically limited marine area. Hence, the BNS and adjacent areas provide an interesting case study and testing area for the development of new research hypotheses and continued multidisciplinary research that can be relevant for other marine regions. This is particularly true for research conducted in the context of large-scale interventions (e.g. energy infrastructures, coastal protection, seabed exploitation) and in applying the ecosystem approach in the BNS. Moreover, historical data and timeseries are often crucial in underpinning marine policy and (policy) scenarios.

The analysis of the publications of the MRGs suggests that research in the BNS is primarily linked to policy issues such as the implementation of the MSFD and Natura 2000 at sea. Certain calls for projects in the federal research programme BRAIN-be have an explicit link with policy issues attended by federal administrations. The competent authorities and advisory bodies are supported by different 'science-policy' structures which inform the policy and accelerate the transfer of marine research outcomes to science-based policy decisions.

Clusters for innovation in the Blue Economy

The industry and the research institutes are facing the challenge to jointly develop the necessary technological and scientific knowledge to foster innovation in the blue economy. Targeted cooperation between science and industry for a blue economy in Flanders is not new on the agenda: Flanders Maritime Cluster (*FMC*) has supported this mission since 2010. FMC encourages companies to cooperate in the development, demonstration and marketing of innovative solutions in the context of the Blue Economy and sustainable coastal and ocean management. In addition to networking and promotion of skills and competences, pilot projects are being implemented to stimulate the valorisation of knowledge and cross-sectoral innovation. Furthermore, the *Flemish Aquaculture Platform*, the *Flemish Algae Platform*, the *Flemish Marine Biotechnology Platform*, the *Blue Energy Cluster* (Factories for the Future), *OWI-Lab*, the Flemish Industrial Biotech Cluster (*CINBIOS*) and the Flanders Innovation Hub for Sustainable Chemistry (*FISCH*) have taken up this role for specific sectors of the Blue Economy in Flanders.

In parallel with the restructuring of the agencies that support the technology and innovation landscape in Flanders, it is crucial for an efficient Blue Economy (COM (2012) 494) and Blue Innovation (COM (2014) 254) to support the development of marine clusters of SMEs, larger companies and research institutes. Through these marine clusters, partners can initiate joint projects and add international leverage to their expertise. An initial analysis of project-based collaborations[15] shows that initiatives were launched between science and industry around some of the growth sectors of the Blue Economy. The largest share of public funding in these innovative projects focus on blue energy (28% of the total analysed budget), aquaculture (23%), marine biotechnology (13%), sensors and monitoring techniques (9%) and offshore engineering and materials (9%) (figure 22).

[13] *Project lead Plants and Lead Companies*, VOKA.
[14] Analysis based on peer-reviewed and VABB publications of the MRG 2008-2014 (see also **Inventory of marine research**).
[15] Analysis of the available funding resources, based on the screening of MRGs in the project databases of FP7, ERDF, BELSPO, IWT and FWO between 2008 and 2014, total analysed budget 43 million euros.

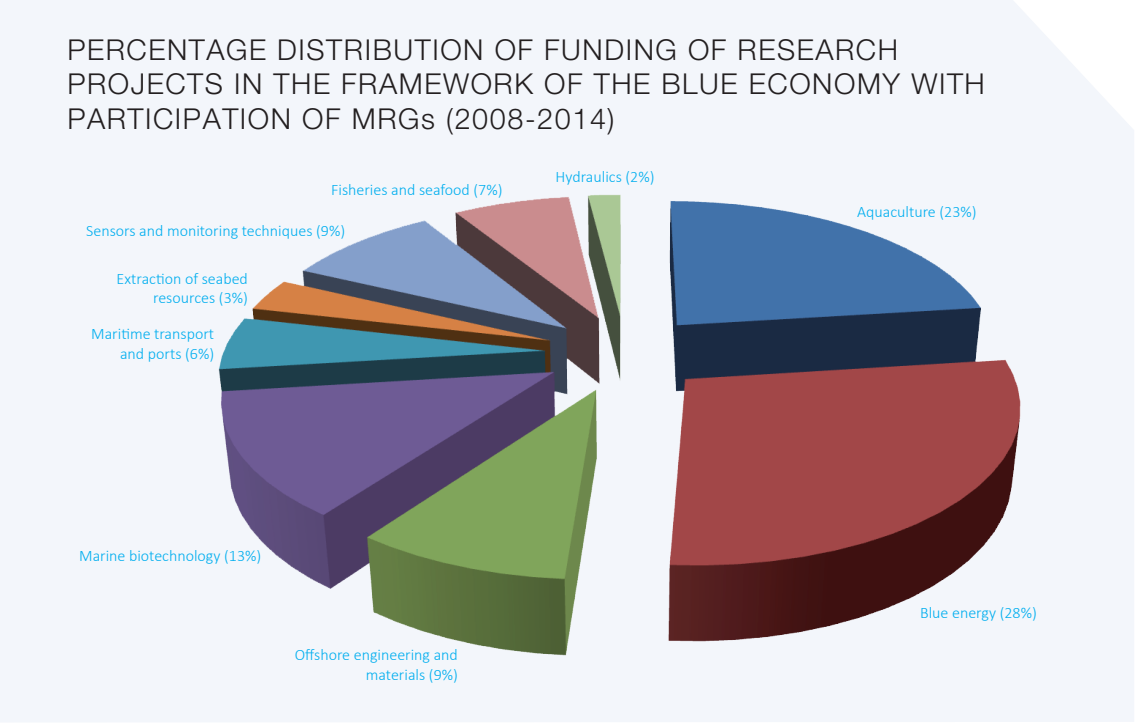

Figure 22. Distribution of the funding of research projects with participations of MRGs* (2008-2014), according to the sector of the Blue Economy. N = 124 projects (Source: IWT, FWO, BELSPO, ERDF and FP7 project databases). * For IWT, FWO and BELSPO the total project budget is considered. FP7 and ERDF projects only take the project budget for Belgian partner(s) into account.

In cooperation with the maritime industry, a coordinated approach is developend for education and training opportunities of qualified staff (e.g. Technical University Alliance for economic transformation in West Flanders (*TUA West*), *Greenbridge*, European Marine Biological Resources Centre (*EMBRC*)).

GLOBAL CHALLENGES: POSITIONING OF BELGIAN MARINE RESEARCH IN THE INTERNATIONAL RESEARCH COMMUNITY

Internationalisation

A significant share of the research of the MRGs in Flanders and Belgium is conducted in the framework of international networks and cooperation with foreign experts. This is evident from the cooperation in European projects (see **Inventory of marine research**) and the analysis of the authors of scientific publications of the MRGs. This analysis shows that in 68% of the publications in the period 2008-2014, at least one foreign (co)author was involved (international co-publications). The international (co)authors come from 83 different countries (figure 23). The MRGs also score above the world average with regard to the citation of their work. Hence, the increased international cooperation in marine research can be directly linked to the enhanced citation rates. Indeed, it is generally known that international co-publications receive on average more citations than publications without participation of foreign (co)authors (*Debackere & Veugelers 2013*). An analysis of the geographical focus of the publications confirms the international scope of the Belgian marine research community: 75% of the analysed publications refers to study areas with an international perspective (Europe and worldwide).

Besides the strength of international cooperation, the long-term scope of marine research and the high data density in the BNS offer unique opportunities to test new research hypotheses. The knowledge and expertise available for the BNS are therefore often exported as a case-study and highly valued in international project consortia. Examples include marine spatial planning and the development of offshore technologies, among others, for the blue energy sector.

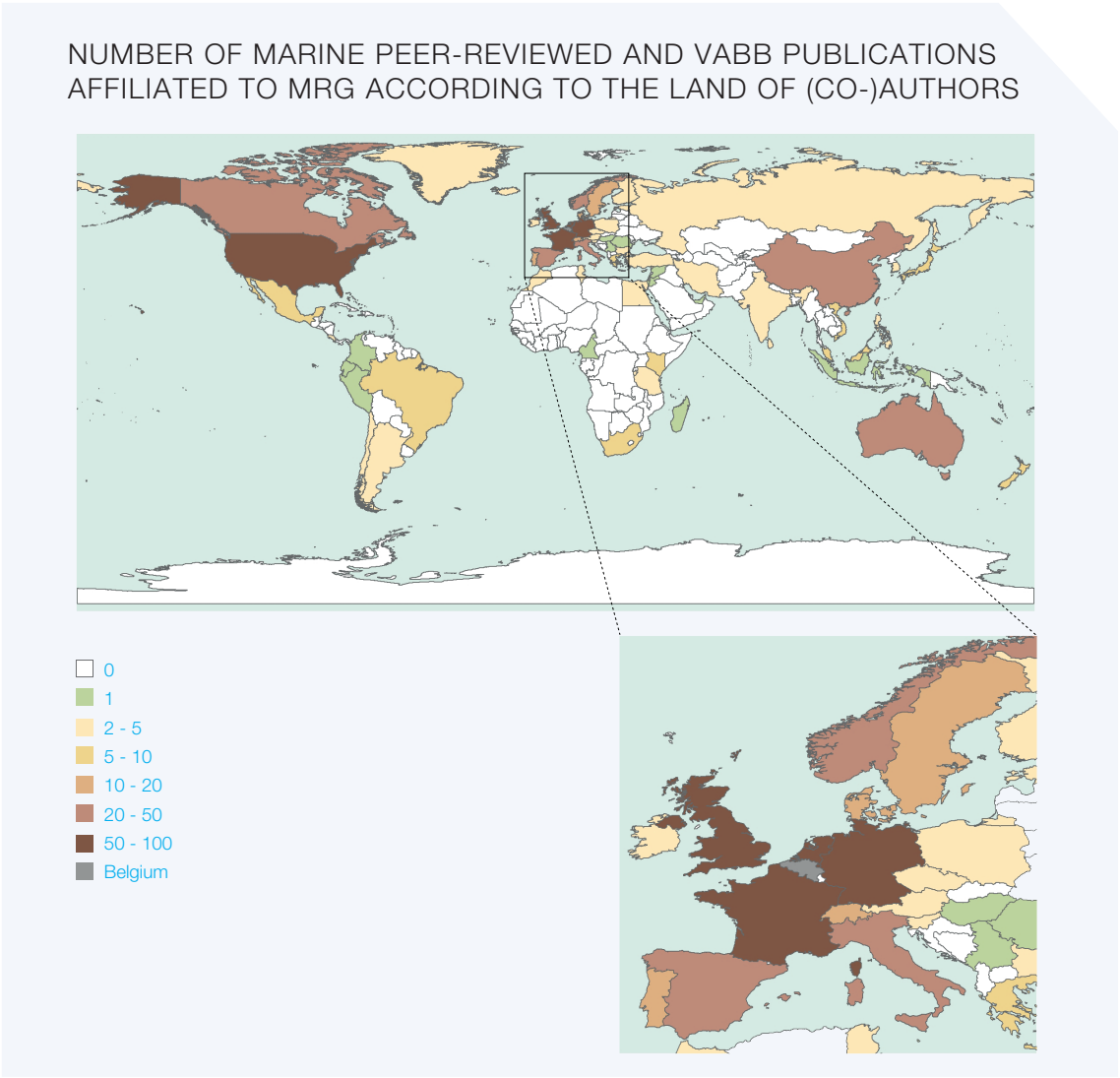

Figure 23. Geographical visualisation of international cooperation, based on the international co-publications of MRGs between 2008 and 2014 (number of marine peer-reviewed and VABB publications of the MRGs by country of affiliation of (co)authors) (see Inventory of marine research).

Research infrastructure is a leverage for (international) cooperation

The research infrastructures in Flanders and Belgium (*Pirlet et al. 2015b*) provide an important leverage for co-operation: in addition to serving the needs of regional and national research, research infrastructure is also deployed in the framework of international cooperation. This is particularly the case for research vessels. The scientific publications of the MRGs in 2013 refer to cooperation with at least 31 different research vessels from 14 different countries. The analysis of the research output highlights the importance of permanent access to these infrastructures and networks to maintain the current international leading position of Belgian marine research. This is particularly the case for seagoing research. In this regard, the access to two complementary research vessels is a key issue for the marine research community in Flanders and Belgium. Also, the first steps are being taken to implement a joint offshore testing- and research infrastructure for marine research institutes and industry (*POM West-Vlaanderen 2015*). Along with the further development of the facilities at the Marine Station Ostend (*MSO*, VLIZ), continued efforts aim for an increased access to collections and specimens (EMBRC), data and information, and research instruments.

Science sharing as a modality in development cooperation

One of the important issues in the context of globalisation is the openness in addressing the major global problems (*Dierick et al. 2005*), in particular for those issues that are high on the agenda of developing countries. Belgium and Flanders have gained relevant experience in marine science sharing in the context of development cooperation (e.g. *VLIR-UOS*, see above). In the marine context, the alignment of research agendas is one of the aspects of science sharing. Flanders plays a leading role in the marine science collaboration with Kenya (*KMFRI*), in particular in the deployment of the RV Mtafiti (former RV Zeeleeuw) in the Indian Ocean which is the least studied oceanic region worldwide. Flanders also supports global marine and coastal-related programmes through the Flanders-UNESCO Science Trust Funds.

Outcome

Despite the 'decentralisation' of marine research in Flanders and Belgium, it has achieved a leading position both at a regional and international level. Capacities are in place to perform multidisciplinary marine research in a broad range of research areas. A sense of collectivity is needed in this international and European context to develop a coherent vision for research topics, technological requirements and infrastructure needs. Structural support for partnerships - including sience-industry - is one of the pillars of our knowledge society and is key in addressing the grand challenges for the current and future marine research.

Flanders as an international partner in marine research

In the policy note (*Beleidsnota (2014-2019)*) of the Flemish minister competent for science, technology and innovation, Philippe Muyters, the priorities for the R&D policy are aligned with the grand challenges at an international and European level. The current coalition agreement of the Flemish government (*Flemish Government 2014*) reconfirms its commitment to the objective of the *Pact 2020*: 'By 2020 Flanders aims to be among the top five European regions with an employment rate of 76% and a budget of 3% of its GDP for research and development'.

In a small region like Flanders, upscaling is a prerequisite to ensure a competitive position in the long term. Cornerstones in this policy are: excellence in scientific research and education and a strong collaboration between science, industry and government for the valorisation of knowledge and innovative applications for the global market. Infrastructures that support research and technology developments are an important pillar in this regard.

The *Hercules Foundation* is the funding instrument of the Flemish government for investments in large- and medium-scale infrastructures for fundamental and strategic research in all scientific disciplines. The European Strategy Forum on Research Infrastructures (*ESFRI*) identifies the needs of the EU member states for pan-European research infrastructures and acts as a consultation platform between member states to achieve these infrastructures. Flanders is participating in five projects within the ESFRI framework (via the Hercules Foundation), three of which have a relevance for marine research: the Integrated Carbon Observation System (*ICOS*), the e-Science European Infrastructure for Biodiversity and Ecosystem Research (*LifeWatch*) and the European Marine Biological Resource Centre (*EMBRC*). EMBRC is a distributed European research infrastructure that integrated the expertise and resources that are present in leading marine biology research centres and stations in Europe. Flanders is also represented in networks and organisations that aim for an optimal use of large-scale infrastructures on a European level, e.g. the European Research Vessel Operators (*ERVO*). Furthermore, Flanders plays an active role in global networks that focus on information management and the standardisation and integration of marine data (e.g. *Aphia*, *WoRMS*, *OBIS*, *EMODnet*, *IODE*, etc.).

In October 1999, Flanders Marine Institute (*VLIZ*) was established which acts as a coordination and information platform for marine research in Flanders. VLIZ is located on the Innovocean site in Ostend. This site has gained an important international reputation due the presence of renowned international partners:

Since 2005, the Flemish government provides structural support for the the UNESCO/IOC Project Office (*IODE Project Office*) through the provision of office space, local staff and operational funding (0.54 million euros). The Flanders-UNESCO Science Trust Funds (FUST) contributes an additional 1.53 million euros per year via UNESCO. Approximately 60% of this budget is dedicated to the support of marine and coastal-related programmes and projects. With this support, Flanders contributes to the international coordination efforts in the fields of oceanography and capacity building, and stimulates the promotion of the sustainable development of coastal areas worldwide.

In 2012, the European Commissioner for Maritime Affairs and Fisheries decided to accept the offer of the Flemish government to host the central secretariat of the European Marine Observation and Data Network (*EMODnet*) on the InnovOcean site in Ostend (a annual subsidy of 180,000 euros). EMODnet is the central pillar of the European initiative Marine Knowledge 2020 (COM (2010) 461).

The European Marine Board (*EMB*) was founded in 1995 to enhance the coordination between European marine research organisations - both the research and research-funding bodies - and to develop a strategy for marine sciences in Europe. Since 2006, the secretariat of this European forum for marine sciences is hosted at the InnovOcean site. VLIZ is the representative of FWO in the EMB (since 2014 as chairman of the Board).

Flanders and Belgium have actively supported the development of *JPI Oceans* since its early stages. In addition, the Flemish government contributes to JPI Oceans (a subsidy of 200,000 euros per year) and by seconding VLIZ staff to the JPI Oceans secretariat since 2011. In 2012, the Coordination and Support Action (CSA) Oceans (FP7) started, with eleven partners from nine different countries joining forces towards the operationalisation of JPI Oceans.

These concerted efforts bring marine research in Flanders closer to the relevant actors in a European and global context. They stimulate participation in international networks and aim for a more integrated and multidisciplinary approach in marine research.

Legislation reference list

Table with international agreements, conventions, etc.

INTERNATIONAL AGREEMENTS, CONVENTIONS, ETC.			
Abbreviations	Title	Year of conclusion	Year of entering into force
UNCLOS	United Nations Convention on the Law of the Sea	1982	1994
Bonn Agreement	Agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances	1983	1989
ASCOBANS	Agreement on the conservation of small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas	1991	1994
OSPAR Convention	The Convention for the Protection of the marine Environment of the North-East Atlantic	1992	1998
HELCOM	The Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area	1992	
Bucharest Convention	The Bucharest Convention on the Protection of the Black Sea against Pollution	1992	
Barcelona Convention	The Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean	1995	

Table with European legislation. The consolidated version of this legislation is available on *Eurlex*.

EUROPEAN LEGISLATION			
Abbreviations	Title	Year	Number
Directives			
Habitats Directive	Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora	1992	43
Water Framework Directive	Directive 2000/60/EC establishing a framework for Community action in the field of water policy	2000	60
Marine Strategy Framework Directive	Directive 2008/56/EC establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Birds Directive	Directive 2009/147/EC on the conservation of wild birds	2009	147
	Directive 2014/89/EU establishing a framework for maritime spatial planning	2014	89
Regulations			
	Regulation (EU) No 1290/2013 of the European Parliament and of the Council of 11 December 2013 laying down the rules for participation and dissemination in "Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020)" and repealing Regulation (EC) No 1906/2006 Text with EEA	2013	1290
Common Fisheries Policy	Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC	2013	1380
Other			
Integrated Maritime Policy	Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - An Integrated Maritime Policy for the European Union	2007	575

EUROPEAN LEGISLATION (continuation)			
Abbreviations	Title	Year	Number
	Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions - A European strategy for marine and maritime research : a coherent European research area framework in support of a sustainable use of oceans and seas	2008	534
	Communication from the Commission to the Council the European Parliament, the European Economic and Social Committee and the Committee of the Regions - Towards the integration of maritime surveillance: A common information sharing environment for the EU maritime domain	2009	538
Marine Knowledge 2020	Communication from the Commission: Marine Knowledge 2020 marine data and observation for smart and sustainable growth	2010	461
	Communication from the Commission: Blue Growth opportunities for marine and maritime sustainable growth	2012	494
Limassol Declaration	Declaration of the European Ministers responsible for the Integrated Maritime Policy and the European Commission, on a Marine and Maritime Agenda for growth and jobs	2012	
	Communication from the Commission: Action Plan for a Maritime Strategy in the Atlantic area Delivering smart, sustainable and inclusive growth	2013	279
	Communication from the Commission: Innovation in the Blue Economy: realising the potential of our seas and oceans for jobs and growth	2014	254

Table with Belgian and Flemish legislation. The consolidated version of this legislation is available on *Belgisch staatsblad* and the *Justel-databases*.

BELGIAN AND FLEMISH LEGISLATION		
Date	Title	File number
Laws		
Bijzondere wet van 8 augustus 1980	Bijzondere wet tot hervorming der instellingen	1980-08-08/02
Royal decrees		
KB van 22 augustus 2006	Koninklijk besluit tot wijziging van het KB/WIB 92 op het stuk van de aangifte in de bedrijfsvoorheffing	2006-08-22/34
Decrees		
Decreet van 30 april 2009	Decreet betreffende de organisatie en financiering van het wetenschaps- en innovatiebeleid	2009-04-30/A0